

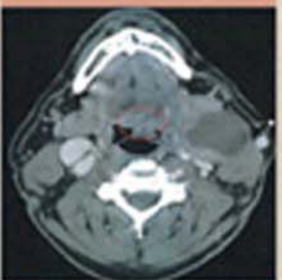

Master Techniques in Otolaryngology–Head and Neck Surgery

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HEAD AND NECK SURGERY

Larynx, Hypopharynx, Oropharynx, Oral Cavity and Neck

VOLUME 1

SERIES EDITOR
EUGENE N. MYERS

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Head and Neck Surgery

LARYNX, HYPOPHARYNX, OROPHARYNX,
ORAL CAVITY AND NECK

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Volume 1
Robert L. Ferris, MD, PhD, FACS

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Head and Neck Surgery: Thyroid, Parathyroid, Salivary Glands, Paranasal Sinuses and Nasopharynx
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This series of books is dedicated to Barbara, my wife and best pal.

Our daughter, Marjorie Fulbright, her husband Cary and their sons,
Alexander F. Fulbright and Charles J. Fulbright.

Our son, Jeffrey N. Myers, MD, PhD, his wife Lisa and their sons
Keith N. Myers, Brett A. Myers, and Blake D. Myers.

All of whom I love and cherish.

Eugene N. Myers

The conception, development, and realization of a large new effort such as this requires much devotion and support from staff and loved ones. In particular, I would like to dedicate this book to my phenomenally supportive and successful wife, Laura, without whom I could not have accomplished very many things in my career. I also appreciate the close mentoring relationship and guidance I have enjoyed over many years from Dr. Eugene N. Myers (Series Editor), who continues to provide opportunities for my career growth and contributions to the field of head and neck surgery.

Robert L. Ferris

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Foreword

Master Techniques in Otolaryngology—Head and Neck Surgery occupies a unique place in the pantheon of outstanding textbooks in the field of head and neck surgery. The topics are highly technical approaches to the field of head and neck oncology dealing with an extensive variety of both benign and malignant pathologies. The description of the surgery is accompanied by outstanding illustrations. This text is unique because each chapter is authored by an individual acknowledged to be a thought leader in the field without the luxury of contributions made by residents or fellows.

The chapters are carefully edited to reflect the effective style of Dr. Eugene N. Myers. The result is a true compendium of expert advice on nearly every topic in head and neck oncology. This reference will be a valuable addition to the library of even the most experienced surgeon, as it offers an opportunity to compare and contrast your personal approach to the methodology currently being taught by international experts.

Jonas T. Johnson, MD, FACS
The Dr. Eugene N. Myers Professor and Chair of Otolaryngology
University of Pittsburgh School of Medicine

Series Preface

Since its inception in 1994, the *Master Techniques in Orthopedic Surgery* series has become the go to text for surgeons in training and in practice. The user-friendly style of providing and illustrating authoritative information on a broad spectrum of techniques of orthopaedic surgery obviously filled a need in orthopaedic educational materials. The format has become a standard against which others are compared, and there are now 13 volumes in the series with other volumes in the planning phase.

When I was approached to be the series editor, I already knew what a daunting task it would be from my previous experience with editing surgical texts, but I felt this unique approach could become a valuable fixture in the catalogue of literature on surgery in all the subspecialty fields of Otolaryngology. This first edition includes volumes on Head and Neck Oncology, Reconstructive Surgery of the Head and Neck, Cranial Base Surgery, Rhinology, Aesthetic Surgery, and Otology and Lateral Skull Base Surgery.

I have recruited real masters to be volume editors including Robert L. Ferris, Eric Genden, Carl H. Snyderman and Paul Gardner, David Kennedy, Wayne Larrabee and James Ridgeway, and J. Thomas Roland, respectively. Having a separate volume on Reconstructive Surgery of the Head and Neck as a separate companion piece for the volume on Head and Neck Oncology is somewhat nontraditional but enabled us to include more topics.

I do hope that you will find the *Master Techniques* to be a useful addition to your surgical armamentarium for the benefit of your patients.

Eugene N. Myers, MD
Series Editor

Preface

Learning surgical techniques, as well as particular operations, is a rite of passage during training and continues afterward. Often we learn from our mentors and colleagues their well thought-out technical approaches and rationale for each approach and surgical maneuver, ultimately creating a hybrid of preferences and surgical style unique to each individual surgeon. Nonetheless, surgical techniques have many aspects in common to different individuals, conjoined by the relevant anatomy and its distortion often by neoplastic pathology. Thus, we endeavor to provide a compilation of individual approaches to unique as well as common surgical procedures, articulated by a single author who is an acknowledged surgical leader, a “Master” of each technique. In this new and unique volume, we have endeavored to transmit, through an outstanding group of world-renowned surgeon-authors, the rational for a particular surgical procedure and the technical details.

Often a surgical atlas is a composite of techniques blended together and usually written primarily by younger, early-stage surgical trainees (fellow or resident) on behalf of the more senior authors. However, we set out with the express intent to bypass this traditional approach, and instead to create single-author chapters written by the master surgeon herself/himself. The effort associated with this was greater for each individual surgeon, since they had to spend more time than usual writing the technical details of their particular assigned surgical procedure. The product is an outstanding and unique compilation of technical material, rationale, preoperative, intraoperative, and postoperative pearls (accompanied by various pitfalls to avoid).

The reader benefits from these single-author contributions from world-renowned surgical scholars, the Masters themselves, many of whom designed, refined, or in fact created the surgical technique authored and promulgated in each chapter. They hand-selected or created color pictures, videos, and sketches made exclusively for this edition in the vast majority of cases. We consider this volume a unique contribution to the surgical field not only for residents and fellows but also for advanced trainees and for ongoing surgical practitioners familiar with a particular surgical approach in their own practices.

We are deeply appreciative of the efforts of our colleagues, the Masters, who agreed to such an unusual and protean task, to describe their assigned technique in the first person as a single-author chapter. Our appreciation will be exceeded, in our opinion, by the benefit of their contribution to the head and neck surgical community who receive the fruits of years of refinement and development of these surgical approaches. Ultimately our patients stand to reap the rewards of this new set of volumes, which will hopefully enrich our care of patients and the positive clinical outcomes they experience.

Robert L. Ferris, MD, PhD, FACS

Acknowledgments

I would like to acknowledge Jonas T. Johnson, MD, for providing me with the stimulus to take on the task of editing a new project—*Master Techniques in Otolaryngology—Head and Neck Surgery*. It has proved to be a daunting task but I believe in the positive impact this will have on those doing head and neck surgery and their patients.

I also acknowledge the dedicated assistance of Agnes C. Zachoszcz and Charmaine Wallace in the preparation of the book.

I also gratefully acknowledge Robert Hurley who recruited me into the project and Ryan Shaw, his successor, for his strong support. David Murphy Jr, who had the daunting task of supplying the technical backup and put the book together.

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John I. Song

INTRODUCTION

Due to its prominent location on the face, cancer of the lip is usually diagnosed early and is usually successfully treated. The American Joint Committee on Cancer defines the lips as part of the oral cavity that "begins at the junction of the vermilion border with the skin and includes only the vermilion surface or that portion of the lip that comes into contact with the opposing lip." Unlike other malignancies of the oral cavity, cancer of the lip is more likely due to the cumulative damage caused by ultraviolet (UV) radiation than by tobacco and alcohol abuse. The lips are especially vulnerable to UV radiation as they lack a protective pigmented layer. Prolonged exposure to sunlight has been shown to cause a loss of elastic fibers, atrophy of the vermilion, as well as hyperkeratosis and atypia of the underlying cells. Severe UV damage can result in *actinic cheilitis* of the lips (chronic scaling and crusting of the vermilion) similar to actinic keratoses seen in sun-damaged skin.

HISTORY

A thorough history of sun exposure, including frequency of sunburns as a child, should be elicited. As with other skin cancers, Fitzpatrick skin typing, including eye color, hair color, and complexion, should be noted. UV-induced lip cancer has a higher incidence in individuals with fair complexion, with outdoor occupations, and those living in sunbelt regions. Therefore, a fair-complexioned individual (Fitzpatrick Type 1 and 2) with cancer of the lip should have a thorough evaluation of the exposed skin of the head and neck to search for a second primary cancer of the skin. Certain smoking habits such as pipe smoking are thought to increase the risks of cancer of the lip as the permeability of some pipe stems can transfer the heat energy directly to the lower lip. The mechanical and thermal injury to the vermilion is thought to be an important cofactor in the carcinogenesis of the lip.

Immunosuppression related to organ transplantation has been associated with squamous cell carcinoma (SCC) of the skin. The lifetime incidence of lip cancer is increased 20- to 30-fold in recipients of renal transplants. These patients develop cancer of the lip at an earlier age and tend to have multiple cancers of the skin. Chronic infection from sexually transmitted diseases, including syphilis or herpes simplex virus, had been previously thought to promote carcinogenesis in the oral cavity, but the evidence for this is inconclusive. Human papillomavirus (HPV), which has been identified as an important cause of certain SCCs of the oropharynx, may play a role in some cancers of the lip. HPV has been found in higher rates in some immunosuppressed patients who develop SCCs of the skin. Whether HPV infection is just more prevalent in this patient population or has a direct causal relationship to cancer of the lip is unclear.

PHYSICAL EXAMINATION

There is a higher incidence of cancer of the lower lip (>85%) than the upper lip (2% to 7%) and oral commissure (<1%) presumably due to the greater UV exposure of the lower lip. Carcinoma of the lip typically presents as

a nonhealing erythematous lesion on the lower lip. The lesion may have perioral chapping or crusting and may ulcerate and bleed in advanced stages. Cancer of the lip tends to remain localized for extended periods of time, and most (80% to 90%) present as stage T1 or T2 with growth occurring laterally rather than invading deeply. Bimanual palpation of the lip can give an accurate assessment of its size, especially if the lesion is ulcerated. Inspection of the gingiva and palpation of the teeth should be performed to insure that the tumor has not extended beyond the confines of the lip. A thorough palpation of the nodal basins of the neck is indicated in all but the most superficial lip cancers. The medial portions of the lower lip drain primarily into the submental lymph nodes, while the lateral portions drain primarily into the lymph nodes of the submandibular triangle (Levels Ia and Ib). There are numerous anastomoses between the lymphatic channels of the lower lip, which allows for bilateral metastases from tumors that are on or near the midline. In contrast, there is sparse crossing of the lymphatics of the upper lip. The upper lip drains primarily into the ipsilateral nodal basins of the periparotid, submental, and submandibular lymph nodes. These nodes in turn drain into the upper and middle deep jugular nodes (Level II/III). A thorough examination of the head and neck is routinely performed to look for any second primary cancers.

INDICATIONS

Surgery remains the mainstay of treatment for most cancers of the lip. Lip cancers that involve less than one-third of the lip are amenable to a single-stage en bloc resection with one-stage reconstruction of the lip in most cases (Fig. 1.1). Cosmesis and function are usually restored to high levels. In superficial cancers of the lip that do not involve the deeper layers of the vermilion, Mohs micrographic surgery may give a superior functional result than more standard resection, but overall surgery times may be longer with Mohs. Tumors greater than one-third of the lip are generally not amenable to primary closure, and a local flap (advancement or lip switch such as an Abbe or Estlander flap) is required.

CONTRAINDICATIONS

Perineural invasion of the trigeminal nerve is a relative contraindication for surgical resection if there is extensive involvement of the nerve on preoperative imaging. Ionizing radiation along the entire length of the nerve up to and including the skull base is indicated in these patients, and the primary cancer can be included in the radiation field. In those patients in whom functional and cosmetic results would be compromised by surgical resection, radiation therapy can be used as a primary treatment modality. Lesions that involve more than one-third to one-half of the lip require additional local flap reconstruction and should be considered for more extensive surgery (Fig. 1.2).

PREOPERATIVE PLANNING

Imaging

Most cancers of the lips are of limited size, and additional radiographic studies are usually not indicated. The exception is the patient with hypesthesia or paresthesia of the face or chin that may indicate involvement of the trigeminal nerve. The upper lip is innervated by the second division (V2) of the trigeminal nerve as it enters the face as the infraorbital nerve. The lower lip is innervated by the third division (V3) of the trigeminal nerve by way of the inferior alveolar nerve exiting the mandible as the mental nerve. In these cases, magnetic resonance imaging (MRI) with gadolinium (postcontrast MRI) may be useful in visualizing any enhancement along the

FIGURE 1.1
Ulcerated lesion of the lower lip limited to the vermilion and involving less than one-third of the lip. Biopsy was consistent with SCC.

FIGURE 1.2 SCC of the lower lip presenting as an exophytic lesion. The lesion extends beyond the vermilion and across the midline of the lower lip but spares the commissure. Lesions of this size require reconstruction with bilateral advancement flaps.

infraorbital nerve (V2), mental nerve (V3), or the trigeminal ganglion that may indicate perineural invasion. Enhancement of the bone marrow on the MRI may indicate extension of the cancer into the mandible. In cases where there is suspected involvement of the mandible or maxillary bones, computed tomography (CT) scan should be obtained for staging and treatment planning. The overall sensitivity and specificity of positron emission tomography (PET) can be equal to or even superior to CT and MRI, especially in patients who have had previous radiotherapy or chemotherapy or both.

Diagnosis

Whenever possible, a biopsy should be obtained at the time of initial evaluation. Most lesions of the lips are amenable to biopsy under local anesthesia. While a shave biopsy is more commonly performed, a punch biopsy (2- or 3-mm punch) allows a sampling of all of the layers of the epithelium without obscuring the surgical margins. A punch biopsy may also give more precise pathologic information, including depth of invasion and, in some cases, evidence of perineural or angiolymphatic invasion. If the patient has been biopsied or operated previously, the slides must be obtained and reviewed by a pathologist who specialized in head and neck pathology to verify the diagnosis prior to surgery. Ultrasound has been used to screen for lymph node metastasis that is not otherwise clinically palpable (cN0) and has the added advantage of not exposing the patient to additional radiation. When combined with fine needle aspiration, the specificity of ultrasound-guided cytology can approach 90%. Newer techniques, such as PET, are being used to identify recurrent cancer and lymph node metastasis.

SURGICAL TECHNIQUE

Surgical resection of most cancers of the lip can be performed under either general anesthesia or local anesthesia with conscious sedation. An additional advantage of using local anesthesia in these cases is that the anatomy of the lower lip is not distorted by the endotracheal tube. If a deeper resection into the muscular layers of the lip is anticipated, or if a prolonged reconstruction is anticipated, a general anesthesia with an oral right angle endotracheal tube placed around the commissure or a nasotracheal intubation may be a better option. The surgical field is prepped with povidone–iodine solution. In addition, the oral cavity may be irrigated with an antibiotic solution of 900 mg of clindamycin in 1 L of normal saline. Patients are given perioperative IV antibiotics within 15 minutes prior to incision to cover typical oral flora.

In addition to a standard set of head and neck instruments, an ophthalmology set including small eye fixation hooks, a variety of iris scissors, and Castroviejo needle holders is used for some of the more delicate areas. I prefer a bipolar electrocautery setup with a jewelers bipolar forceps to allow for more precise cauterization and to minimize surrounding thermal injury. Careful measurements of the lesion with 5- to 6-mm margins are carried out on both sides of the cancer. A sterile cotton-tip swab is shaved to a sharp point and used as a quill to mark out the margins using methylene blue dye. A very small amount (<3 mL) of 1% lidocaine with 1:100,000 epinephrine is injected to achieve vasoconstriction without distorting the anatomy. Prior to resection, it is critical to score the junction between the skin and the vermilion very superficially with the tip of a 15-blade inked with methylene blue in order to give a visual reference when realigning this important area.

Lesions limited to the mucosa of the vermilion (superficial cancers, carcinoma in situ (CIS), or severe dysplasia) (Fig. 1.3A) can be managed with a vermilionectomy (lip shave) taking with it a small layer of underlying muscle as a surgical margin (Fig. 1.3B). In these cases, the long axis of resection is oriented along the long axis of the lip as to spare as much of the mucosa of the inner lip, which can then be used as a mucosal flap. Defects of the vermilion up to one-third the length of the lip can be repaired using a sliding mucosal advancement flap from the mucosa of the oral vestibule. A 2- to 3-cm flap of oral mucosa is undermined adjacent to the defect and released on both sides as an advancement flap. The flap is reapproximated to the skin–vermilion border and closed primarily with 5-0 or 6-0 absorbable sutures (Fig. 1.3C). This results in an acceptable cosmesis without microstomia (Fig. 1.3D).

FIGURE 1.3
A: Superficial lesions limited to the vermilion (severe dysplasia, CIS, superficial cancer) can be resected without disruption of the underlying orbicularis muscle. **B:** Resection of lesions limited to the vermilion spares the underlying orbicularis muscle. **C:** Resurfacing of the vermilion is achieved by advancing the buccal mucosa broadly from oral commissure to contralateral commissure. **D:** Six months post-op. There is a slight retraction of the vermilion but overall acceptable cosmesis without microstomia.

Wedge resection: after a standard V-resection has been marked, the lip is firmly grasped (Fig. 1.4A–D). With the aid of an assistant, the labial artery is "pinched" between two fingers on either side of the resection in order to minimize bleeding. The wedge can be resected with a 15-blade or sharp iris scissors. The specimen should be oriented with sutures prior to being sent for frozen section. The labial artery can be cauterized with jewelers bipolar forceps or ligated if its diameter is larger. Additional hemostasis can be achieved using the bipolar forceps at low power to minimize thermal injury.

Once margins have been cleared by frozen section, the closure is begun by first reapproximating the skin–vermilion border previously marked. In general, the wedge defect should be closed in three layers, including the inner mucosal layer, the orbicularis muscle, and the outer vermilion/skin layer. The goal is to work outward from the middle of the orbicularis muscle with the final thin layer of muscle reapproximated with either Vicryl or fast-absorbing chromic suture layer just below the skin. A 4-0 Vicryl is used to reapproximate the orbicularis muscle in an interrupted fashion. While the inner mucosa can also be closed in a similar fashion, I prefer to use a 4-0 chromic as a horizontal mattress suture that better everts the mucosa and allows for a superior closure. Soaking the chromic suture in water prior to use allows it to become more pliable for this delicate task. The outer vermilion/skin is closed in interrupted fashion with a 5-0 or 6-0 nylon suture. The skin closure can be reinforced with Steri-Strip tape placed along the long axis of the lip.

Modified W-wedge resection: if the lesion occupies a larger surface of the vermilion, but does not infiltrate deeply, a W-modification of the wedge can reduce the extent of the excision beyond the lip. A standard V-resection is outlined (Fig. 1.5). The apex of the "V" is shortened by converting it into a "W". In the lower lip, the W-resection is kept outside of the mental subunit whenever possible in order to limit the length of the scar to the skin just inferior to the vermilion border. In this method, the W-resection can be designed to encompass a part of the submental crease in such a way as to incorporate the Y-closure into it, resulting in a better cosmetic appearance (Fig. 1.6).

Advancement flaps for central defects of the lip: central defects up to one-third of the lip will be difficult to close primarily without significant microstomia unless bilateral advancement flaps are used. In the lower lip, the excision is designed such that the arc of advancement is placed along the mental crease, which allows even a long scar to be hidden within the rhytid (Fig. 1.7A–C). In order to advance the flaps, the inner oral mucosa must be adequately excised along with the vermilion resection. In the upper lip, the advancement flap is designed along the nasolabial crease. Great care must be taken to preserve the labial artery and the angular branch of the facial artery just deep and lateral to the nasal ala when the flap is being raised. Small Burow triangles must be excised from the skin just lateral to the nasal ala in order to prevent the flap from protruding along the nasolabial fold. In both types of advancement flaps, meticulous three- or four-layer closure emphasizing the reapproximation of the muscular layer is necessary in order to prevent wound dehiscence and retain functionality.

For most early-stage cancers of the lip, a therapeutic or elective neck dissection is rarely indicated. For those patients in whom a neck dissection is indicated either by clinical examination or by preoperative imaging, it must remembered that cancers of the lower lip, especially those at or near the midline, have a high propensity for bilateral spread due to the decussation of the lymphatics in this area. Neck dissection must surgically address zones Ia and Ib on both sides of the neck in these cases.

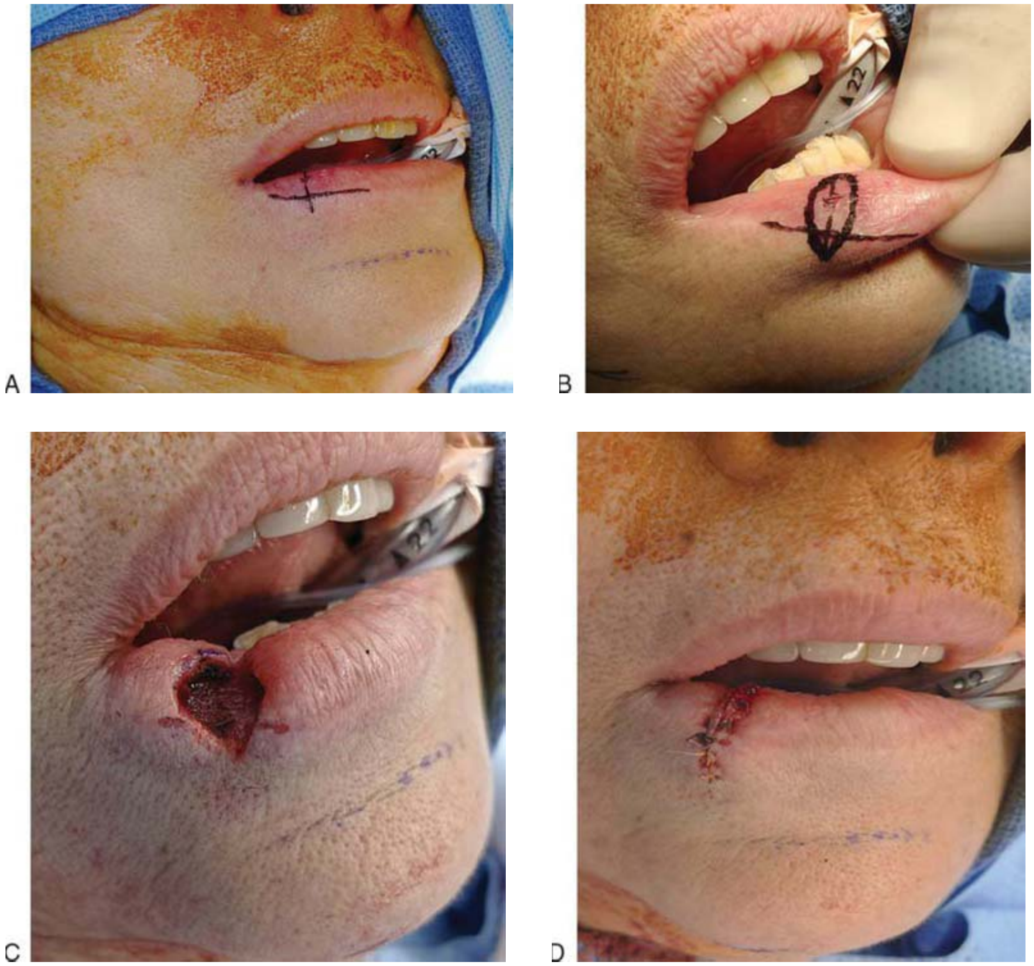

FIGURE 1.4
Wedge resection of the lower lip. **A:** The junction between the skin and the vermilion is carefully marked to give a visual reference when realigning this critical area. **B:** A 5-mm margin is outlined from the central axis of the tumor in an elliptical fashion. **C:** Wedge resection removed a margin of orbicularis muscle and the overlying vermilion. Note that the vermilion–skin junction has been scored using a 15-blade to improve alignment. **D:** Primary closure of the wedge resection. The vermilion was closed using interrupted horizontal mattress sutures to better evert the mucosa. A 5-0 nylon was used to reapproximate the vermilion–skin junction.

POSTOPERATIVE MANAGEMENT

Patients are maintained on oral antibiotics for 3 to 5 days in the postoperative period. Antibiotic ointment is used to cover any suture lines not already covered by steri-strips. This serves to also maintain a moist environment and prevent drying of the lips. The patient's diet depends largely on the extent of the lip resection and the degree of microstomia. In limited wedge resections where there is little tension on the suture line and almost full oral opening, an almost regular diet can be prescribed with the patient educated on avoiding foods that require extensive chewing. The goal is to maintain as little tension on the suture line as possible. In those patients with larger resections and/or advancement flaps, very little chewing is allowed in the postoperative period limiting them to a liquid or soft diet. Oral hygiene can be maintained by using chlorhexidine

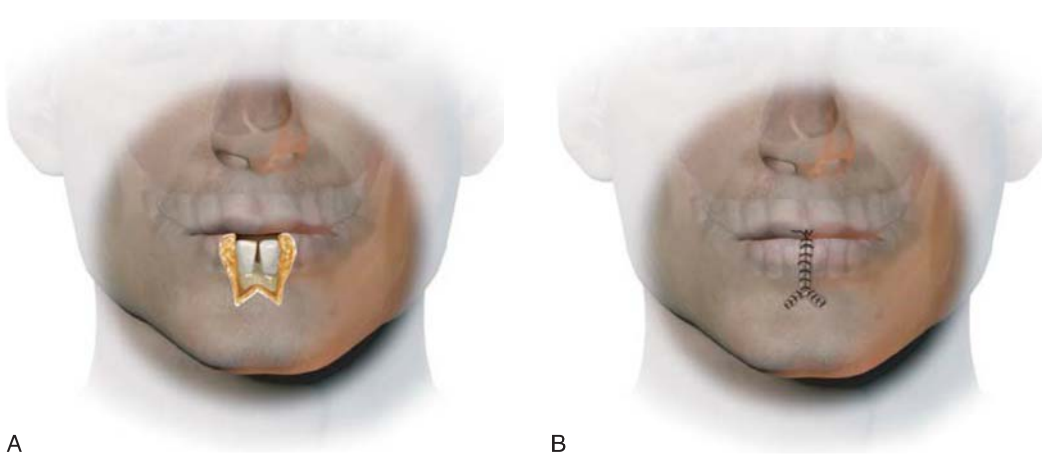

FIGURE 1.5
A: W-resection is outlined extending below the vermilion border. **B:** Closure of W-defect.

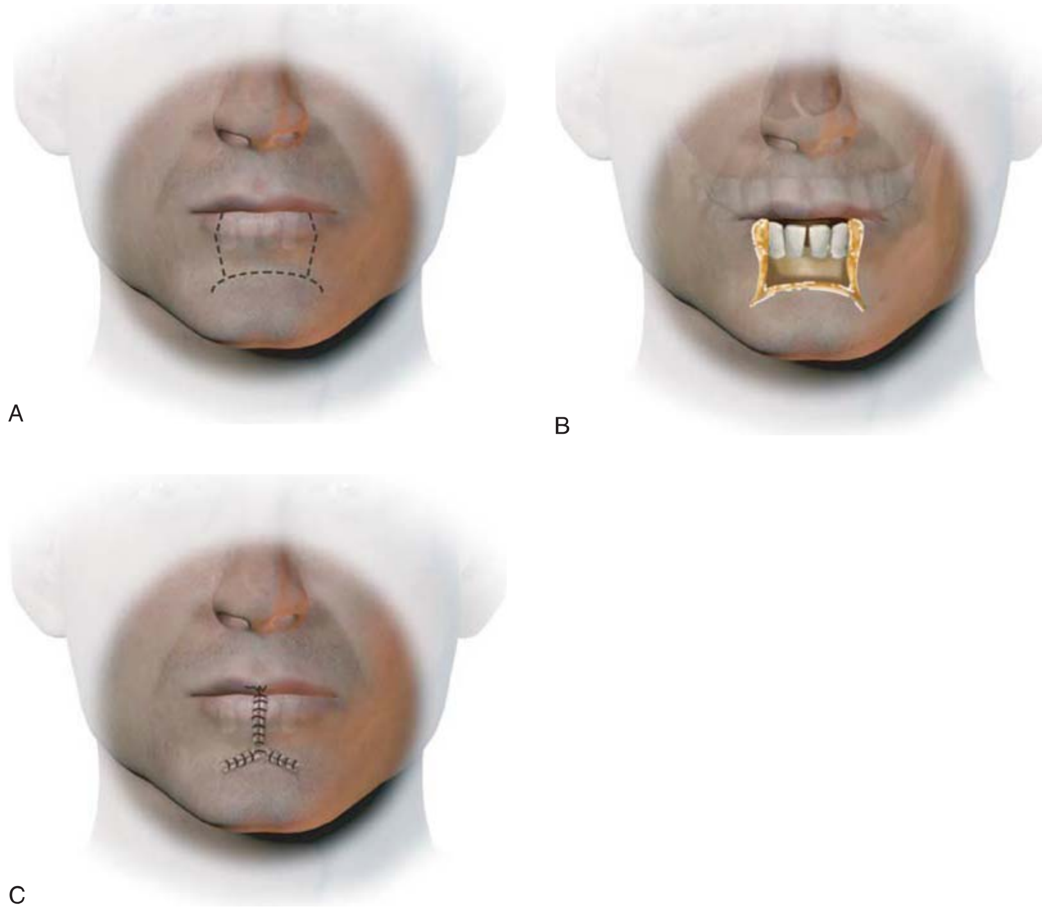

FIGURE 1.6
A–C: The W-resection can be designed to encompass a part of the C-submental crease in a such a way as to incorporate the Y-closure into it, resulting in a better cosmetic appearance.

gluconate (Peridex, Periogard) oral rinse if the patient cannot brush the teeth. The cutaneous nylon sutures can be removed 7 days post-op in uncomplicated cases. In more extensive advancement flaps, nonabsorbing sutures may be removed in 10 to 14 days depending on wound healing. Absorbable sutures such as Vicryl and chromic can be left until the wound has completely healed.

COMPLICATIONS

Poor wound healing resulting in suboptimal cosmetic and functional outcomes is usually the result of infection or technical error. Judicious use of perioperative antibiotics and careful wound care usually can prevent most infections. Failure to carefully align the skin–vermilion border will result in step-off defects with poor cosmesis. Marking the border preoperatively, reapproximating the vermilion border first during reconstruction, aligning the orbicularis muscle layer properly, and meticulous three-layer closure all help to prevent these complications from occurring (Fig. 1.8).

A certain degree of microstomia is unavoidable except in very small resections of the lip (Fig. 1.9A and B). Patient education and informed consent are essential in helping patients expect and manage these sequelae. Post-op speech and swallow therapy can aid in minimizing loss of function in most patients. In clinically significant microstomia limiting oral intake and oral hygiene, various oral appliances are available based on the direction of the stretch (horizontal, vertical, and circumoral) and placement (external and internal). However, in cases of microstomia as a result of cancer resection, these oral appliances have limited utility. Surgical correction of microstomia may be necessary in some of these patients. In less severe microstomia, a commissuroplasty or commissurotomy may be performed as early as 6 to 8 weeks post-op. In this procedure, a skin excision is performed to accommodate a new commissure, and the underlying subcutaneous layers are divided. A new vermilion layer is created by transposing a free mucosal flap (converse) or by rotating a vermilion flap from the opposite lip (Gilles and Millard). In more severe cases of microstomia, augmentation of the lips or commissures may require stair-stepping the orbicularis oris muscles and reapproximating the ends in order to lengthen the corners of the mouth. Patients with moderate-to-severe microstomia may be difficult to intubate in the future.

FIGURE 1.7 **A:** Large wedge resection of the lower lip and bilateral advancement flaps outlined along the submental crease. **B:** Scar at 2 weeks post-op. **C:** Scar at 6 weeks postoperation.

FIGURE 1.8 Postoperative wound breakdown due to failure to adequately close the orbicularis oris muscle layer.

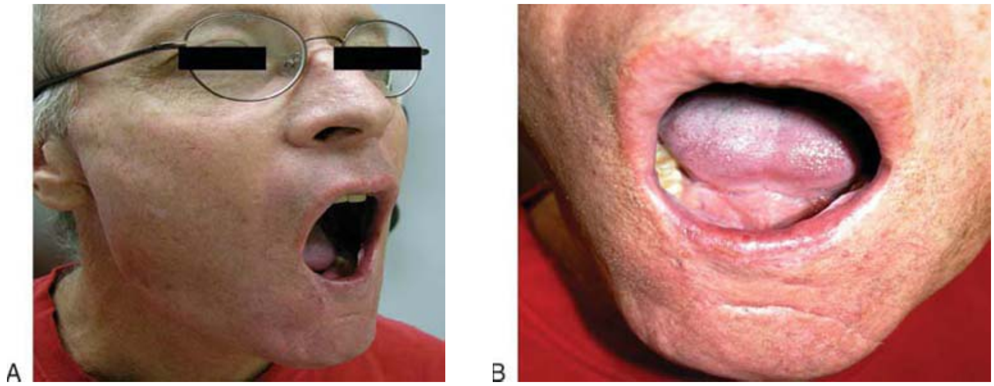

FIGURE 1.9
Microstomia. **A:** Some degree of microstomia is inevitable with larger resections of the lip. This patient had bilateral advancement flaps to close a large lower lip defect. **B:** Despite some microstomia, he has good vermilion reconstruction and acceptable cosmesis with very good functional results.

PEARLS

- In lesions limited to the vermilion, a full-thickness excision of the vermilion with muscle sparing should be performed whenever oncologically possible.
- A wedge resection for lesions beyond the superficial vermilion is the most commonly used surgical excision as a V-shaped, W-shaped, or rectangular excision.
- For optimal cosmesis, the resection should be limited to the anatomic subunit of the lip whenever possible. If surgical excision into adjacent anatomic subunits (i.e., midface, mentum, base of nose) cannot be avoided, the excision should be incorporated into existing relaxed skin tension lines.
- Scoring the skin–vermilion border with a 15-blade gives a visual reference to the closure. This border should be reapproximated first before the rest of the closure.
- To minimize anatomic distortion, a 30-gauge needle is used to infiltrate vasoconstrictive agents into the resection site.

PITFALLS

- Imprecise alignment of the vermilion border will result in a step-off defect and an inferior cosmetic result.
- Primary closure of lip defects is usually not possible if the lesion is greater than one-third of the lip.
- Failure to meticulously close all three layers will result in wound dehiscence and poor functional and cosmetic outcome.
- Advancement flaps for defects up to one-third of the lip will result in some degree of microstomia.

INSTRUMENTS TO HAVE AVAILABLE

- Major head and neck surgical set.
- Separate minor ophthalmologic set with small eye fixation hooks, a variety of iris scissors, and Castroviejo needle holders.
- A bipolar electrocautery set consisting of guarded neurosurgery bipolar forceps and jewelers bipolar forceps.

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2 EXCISION OF CANCER OF THE FLOOR OF THE MOUTH

James W. Rocco

INTRODUCTION

Cancer of the oral cavity accounts for 5% of all cancers in the United States, with a significant proportion of these being squamous cell carcinoma of the floor of the mouth (FOM). A detailed history, physical examination, and preoperative biopsy are essential in establishing the diagnosis. The majority of these patients will have a history of tobacco and alcohol use. Clinical examination and preoperative imaging play a critical role in the diagnostic assessment, therapeutic planning, and successful management of these cancers. Operative techniques for the removal of these cancers are straightforward with early lesions usually being removed through a transoral approach. More advanced cancers often require alternate approaches and may involve partial resection of the ventral tongue or mandible to obtain adequate margins of resection. Close cooperation between the ablative and reconstructive efforts is essential in obtaining clear margins of resection while preserving speech and swallowing function.

HISTORY

A mass arising in the FOM is a common presenting complaint to the health care professional. Due to the wide variety of benign and malignant etiologies possible, a detailed history is the critical first step in patient evaluation (Table 2.1). A prior history of trauma, dental procedures, recent infection, mass or lesion since childhood, past surgery, or cancer may be a vital clue to the origin of the mass. A comprehensive discussion of risk factors for malignancy is also mandatory, and all patients should be queried in detail regarding tobacco and alcohol use, as well as prior radiation exposure, sexually transmitted diseases, and possible immune suppression.

The vast majority of malignant lesions presenting in the FOM are squamous cell carcinoma. In about 50% of these cases, the cancer will be limited to the FOM, although some patients will present with advanced stage cancer with metastasis to the neck. Often a patient will be referred to the otolaryngologist–head and neck surgeon after a dental examination identifies an asymptomatic mass in the early stages of disease. However, with more advanced cancer, it is not uncommon for the patient to present with bleeding, ulceration or pain, foul odor, obstruction of the submandibular duct, or a mass in the neck. In the case of squamous cell carcinoma, these patients are usually male, in the fifth to sixth decades of life, with a history of tobacco and alcohol use. There has also recently been increased awareness of the role of smokeless tobacco in the induction of squamous cell carcinoma of FOM specifically with chewing tobacco showing a relationship to verrucous carcinoma. In addition, outside of the United States such as in India and other areas of Southeast Asia, widespread use of the betel nut shows a strong correlation with FOM and buccal squamous cell cancer. The relationship between human papilloma virus (HPV) infection and oral cancer is not nearly as established and pronounced as for that found in the oropharynx.

The characteristic history of a cancer in the FOM is that of a slowly growing lesion, in some instances submucosal and painless and at other times ulcerated and tender. These lesions can arise in regions of

TABLE 2.1 Lesions Reported in the FOM

Inflammatory, Traumatic or Infectious	Developmental	Neoplasms
Mucous retention cyst (Ranula)	Dermoid cyst	Lipoma
Dermatologic disorders: Behcet disease Bullous pemphigoid Erythema multiforme Lichen planus Pemphigus vulgaris	Epidermoid cyst	Benign salivary gland tumors: Intraductal papilloma Oncocytoma Pleomorphic adenoma Warthin
Necrotizing sialometaplasia	Lymphangioma (cystic hygroma)	Malignant lesions: Metastatic cancer Squamous cell carcinoma Verrucous carcinoma
Infectious: *Candidiasis* Herpangina (Coxsackie A virus) Herpesvirus infection Oral hairy leukoplakia (EBV)	Hemangioma	Nonepidermoid malignancies: Adenocarcinoma Adenoid cystic carcinoma Lymphoma Melanomas Mucoepidermoid carcinoma
Recurrent aphthous stomatitis		Premalignant lesions: Dysplasia Erythroplakia Leukoplakia Lichen planus
Sublingual sialoadenitis		

prior erythroplakia or leukoplakia. Patients often develop ulceration, bleeding, pain, and obstruction of the submandibular duct. The patient should also be questioned about changes in swallowing or articulation, weight loss, aspiration, cough, numbness of the tongue, or skin over the mandible. All of these could be a sign of deep infiltration into the muscular floor or mandible with impaired function as suggested by weakness of the hypoglossal nerve with restricted mobility of the tongue or numbness of the lingual or mental nerves. It is not unusual for cancers with deep muscle invasion to restrict tongue mobility with a subsequent change in both the quality of speech and ease of articulation, as well as a detrimental impact on swallowing function. Patients with far advanced cancers may present with destruction of the anterior segment of the mandible and invasion of the skin of the chin.

PHYSICAL EXAMINATION

Cancer presenting in the FOM should be carefully inspected and the dimensions recorded in the preoperative assessment. It should be noted whether the cancer involves the mucosa or is only submucosal. Bimanual palpation should be used when feasible to determine the extent and depth of any lesion and whether it involves critical structures such as the deep tongue musculature, lingual surface of the mandible, or the ventral anterior tongue. Location of the cancer relative to Wharton ducts, whether it directly involves the ducts, and if the ducts are patent should also be noted. Palpation of the submandibular glands can often be used to express saliva from the ducts, and this technique should be performed on all lesions of the FOM. Specific deficits in the function of the lingual nerve should be evaluated. For those lesions involving or adherent to the lingual aspect of the mandible, care should be taken to note the quality and state of any dentition, whether there are any loose teeth, periodontal disease, and if there is any evidence of numbness in the distribution of the mental nerve bilaterally. For lesions extending deep into the tongue, the physical examination should specifically address the function of the hypoglossal nerve, including mobility of the tongue, as well as articulation and swallowing function. The skin of the chin should be inspected for signs of infiltration. Bimanual palpation can determine possible invasion into the sublingual glands, extension into the submandibular glands, or direct extension into the neck. The presence of a mass in the neck should also be noted. In patients with particularly large lesions that are painful, bleeding and friable, or exophytic, it may be necessary to defer a detailed physical examination until the patient is in the operating room. At the completion of the physical examination, the surgeon should have determined the true and precise extent of the lesion, proposed a definitive surgical approach, and considered different reconstructive options.

INDICATIONS

Surgery remains the most appropriate treatment for cancer of the FOM since radiation therapy is less effective oncologically and causes complications such as radiation caries and osteoradionecrosis of the mandible. The decision to perform surgery for cancer of the FOM is based on many factors including overall patient health, patient life expectancy, specific tumor pathology and behavior, tumor stage and expected morbidity of treatment, reconstructive options, and predicted treatment outcomes. A detailed history and physical, appropriate medical consultation, preoperative radiographic imaging, and intraoperative examination with biopsy followed by pathology evaluation and reconstructive consultation are critical in the proper selection of patients for surgery.

CONTRAINDICATIONS

Contraindications to surgery can be divided into local factors and patient comorbidities. With regard to local factors, the only significant absolute contraindication to surgery would be direct extent of a FOM cancer into the neck with carotid artery encasement or encasement of the carotid artery by metastatic lymph nodes. Relative contraindications include those patients in whom surgical excision, while technically feasible, precludes any significant quality of life in the setting of the patient's wishes based on expected cure rates and associated surgical morbidity. For example, a large T4 FOM cancer requiring excision of facial skin, mandible, tongue, and larynx to achieve negative margins might be better served by a palliative regimen once the diagnosis is established. Distant metastases are a relative contraindication, since in many cases palliative surgical therapy can offer significant benefit by relieving pain and bleeding, eliminating the social isolation from necrotic or infected tumor, and allowing a return to an oral diet, long before distant metastasis ends the patient's life. Patients with significant comorbidities such as dementia, advanced cardiovascular or pulmonary disease, or end-stage renal failure are probably best managed by nonsurgical means.

PREOPERATIVE PLANNING

Biopsy

Incisional biopsy or fine needle aspiration biopsy of FOM lesions are essential tools in the preoperative evaluation of a mass or an ulcer in the FOM. A punch biopsy in the office under local anesthesia followed by frozen section analysis can readily establish the diagnosis at the time of initial evaluation, potentially determine the depth of invasion, and ensure that other critical preoperative planning occurs in the setting of known tumor pathology. In the case of submucosal lesions, which may represent nonmalignant or nonsquamous malignant etiologies, fine needle aspiration can be particularly valuable in establishing a rapid diagnosis and assisting in preoperative therapeutic planning.

Imaging Studies

Imaging studies are mandatory in the preoperative evaluation of a mass in the FOM. Proper imaging provides valuable information regarding the three-dimensional extent of the mass and potential involvement of critical regional structures such as the deep tongue musculature or mandible, identifies direct extension into the submandibular glands or soft tissues of the neck, and can readily identify cervical lymphadenopathy.

A computed tomography (CT) scan of the neck with contrast is a good first choice for a preoperative planning study. In those cases where office or operating room examination is suspicious for invasion of the mandible, a dedicated CT of the mandible (no contrast with bone windows) can also be performed to identify irregularities or erosion of the cortex, as well as to determine the extent of involvement of the mandible to facilitate preoperative surgical and reconstructive planning. If the lesion is poorly defined on CT scan or hidden by extensive dental artifacts, or there is concern for invasion of the deep tongue muscle or direct extension into the neck, a magnetic resonance imaging with contrast is particularly useful in defining the extent of the lesion and potential involvement of critical vasculature structures such as the carotid artery. Routine positron emission tomography scans are not recommended in the preoperative evaluation of lesions of the FOM. However, in the case of malignant tumors, they can aid in demonstrating distant metastases, potentially altering the therapeutic plan.

Preoperative Dental Evaluation

Poor oral hygiene is found in many patients with cancer in the FOM. Consequently, it is necessary that preoperative dental evaluation and appropriate dental care be provided. This is especially important for patients who will receive postoperative radiotherapy. In this setting, it is important that the patient has appropriate

dental prophylaxis, which often consists of restoration or dental extraction, and fluoride for the prevention of radiation caries of the remaining teeth. Teeth within or near the tumor should be extracted at the time of surgical excision.

Comorbidities

Medical comorbidities are common in patients with cancer of the head and neck and can have a significant impact on the outcome of surgical therapy and may even preclude curative therapy as an option. The potential impact of medical comorbidities should be minimized through proper identification in the preoperative evaluation followed by appropriate referral and subsequent medical management to optimize the surgical candidate's health status. Patients with significant comorbidities should be seen by a medical specialist who concentrates on the perioperative medical care of the surgical patient. Special consideration should be given to patients with congestive heart disease, cardiac arrhythmia, peripheral vascular disease, pulmonary disease, renal disease, and other cancers.

Management of anticoagulation in the perioperative period is constantly evolving, and surgeons should access ACCP guidelines for the most current clinical practice guidelines. In general, patients on warfarin/Coumadin should temporarily stop therapy 5 days before surgery and resume it 12 to 24 hours after surgery, assuming adequate hemostasis was achieved and there is no active bleeding. Patients at high risk for thromboembolism should receive bridging anticoagulation therapy that can consist of intravenous unfractionated heparin that should be stopped 4 to 6 hours before surgery, or low molecular weight heparin that should be stopped 24 hours before surgery.

Speech and Swallowing Evaluation

Patients with a cancer of the FOM often demonstrate significant functional impairment in speech and swallowing function at presentation that becomes worse after surgical therapy. In addition to problems with speech, these patients can experience significant difficulties with the oral stage of swallowing. Fortunately, the potentially life-threatening complication of aspiration is uncommon in these lesions. Preoperative assessment and aggressive speech and swallowing therapy in the postoperative setting can establish realistic expectations and help the patient maximize speech and swallowing function after treatment.

Airway Management

The time to plan surgical airway management is in the preoperative setting and requires a clear discussion between the surgeon and the anesthesia staff. Many lesions of the FOM are small and present no significant airway challenges other than the need for nasotracheal intubation to allow adequate exposure for resection at the time of surgery. However, even small lesions of the FOM that are reconstructed using a skin graft and bolster may result in a challenging postoperative airway and ultimately require tracheostomy for airway stability and tracheobronchial toilet, until the bolster is removed. More extensive lesions of the FOM with tongue or mandible involvement often require fiberoptic intubation followed by tracheostomy after intubation or awake tracheostomy to provide a stable and safe airway during surgery and the postoperative period. The majority of patients undergoing microvascular free-flap reconstruction require a tracheostomy for airway stability in the postoperative period.

Informed Consent

Due to the complexity of the FOM, its proximity to critical structures, functional role in speech and swallowing, and impact on appearance, surgery on the FOM requires a detailed preoperative discussion to achieve informed consent. Patients should be advised on issues common to all surgeries as well as those specific to the FOM operative site. The surgeon should carefully describe likely outcomes, as well as potential complications and their consequences. At a minimum, potential for wound breakdown or fistula, nerve injury or sacrifice and their sequelae and chance for recovery, need for further surgery, impact of a positive or close margin, expected changes in speech and swallowing function, mandible nonunion or fracture, and dental loss must be discussed.

SURGICAL TECHNIQUE

Surgery remains the main treatment modality for FOM malignancies. The critical issues to address prior to undertaking surgical intervention include a confirmed pathologic diagnosis, accurate three-dimensional assessment of the mass through preoperative examination and imaging, accurate TNM staging of the disease, an assessment of the medical condition of the patient, and an estimate of the expected morbidity of treatment. At the time of the planned surgical procedure, it is essential that appropriate consideration has

been given to airway management, the surgical approach to the primary cancer, the need for neck dissection or mandibular resection, the plan for reconstruction, and an outline of postoperative management such as the need for ICU care.

Anatomic Considerations

Proper understanding of the complexity of the anatomy of the FOM is vital to the proper surgical management of these cancers. Detailed understanding will allow the surgeon to obtain tumor-free margins while maximizing speech and swallowing function. Critical to planning the surgical approach for tumor removal is a true three-dimensional understanding of resection boundaries, important structures, and lymphatic drainage patterns (Fig. 2.1). The FOM subsite of the oral cavity is contained anterior and laterally within the horseshoe-shaped lower gingival and inferior alveolar ridge of the inner mandible and posteriorly by both the ventral surface of the tongue medially and the anterior pillar of the tonsils laterally. It is divided into left and right halves by the lingual frenulum, which is closely approximated by the openings of Wharton ducts on either side. The mucosa of the anterior FOM lies over the mylohyoid, which forms a muscular sling extending from the lateral inferior mandible to the hyoid bone medially. Three muscles: the genioglossus, hyoglossus, and styloglossus lie between the mucosa and mylohyoid to support the FOM. Deep to the FOM mucosa and lateral to the hyoglossus muscle are three critical structures, the lingual and hypoglossal nerves and the sublingual gland. The lingual artery, a branch of the external carotid, lies medial to the hyoglossus and represents the arterial supply. The sublingual veins are just inferior to the FOM mucosa. The sublingual and submandibular glands drain into the FOM via the Bartholin and Wharton ducts. The anterior FOM has both superficial and deep lymphatics that drain into the submental nodes, both ipsilateral and contralateral submandibular nodes, and the ipsilateral submandibular and superior jugular nodes respectively. The posterior FOM lymphatics drain directly into the ipsilateral jugulodigastric and jugulocarotid nodes.

Airway Management

After review of the informed consent and discussion with anesthesia colleagues, the patient is placed under general anesthesia without paralytic agents. For smaller cancers, nasotracheal intubation should be performed to insure adequate exposure, thereby avoiding the interference of an oral endotracheal tube with the planned resection. Prior to entering the operating room, appropriate nasal anesthesia and decongestion should be obtained for patient comfort during the nasotracheal intubation. The liberal use of Afrin and lidocaine jelly on a nasal trumpet is often adequate to both anesthetize and dilate the nasal mucosa in preparation for nasotracheal intubation. Nasotracheal intubation is a relatively common technique for most anesthesiologists; however, if there is significant nasal obstruction or deviation it is wise for the otolaryngologist–head and neck surgeon to perform this procedure to avoid significant tears in the nasal mucosa or subsequent epistaxis. In rare cases, nasotracheal intubation will be impossible, and the surgeon will have to choose between oral intubation alone and intubation followed by elective tracheostomy. Once intubated, care needs to be taken to secure the nasotracheal tube to prevent inappropriate extubation, which is often done with a 2-0 silk suture placed through the anterior septum with a loose knot to prevent septal necrosis. In addition, to prevent nasal alar necrosis, a wedge of Gelfoam or Xeroform should be placed between the nasotracheal tube and the nasal ala to make sure the contact from the nasotracheal tube is distributed over a larger alar surface area (Fig. 2.2). In cases where a more extensive resection involving the ventral tongue, deep FOM musculature, or mandible is planned, an elective tracheostomy should be performed after the patient undergoes endotracheal or fiberoptic intubation with the additional

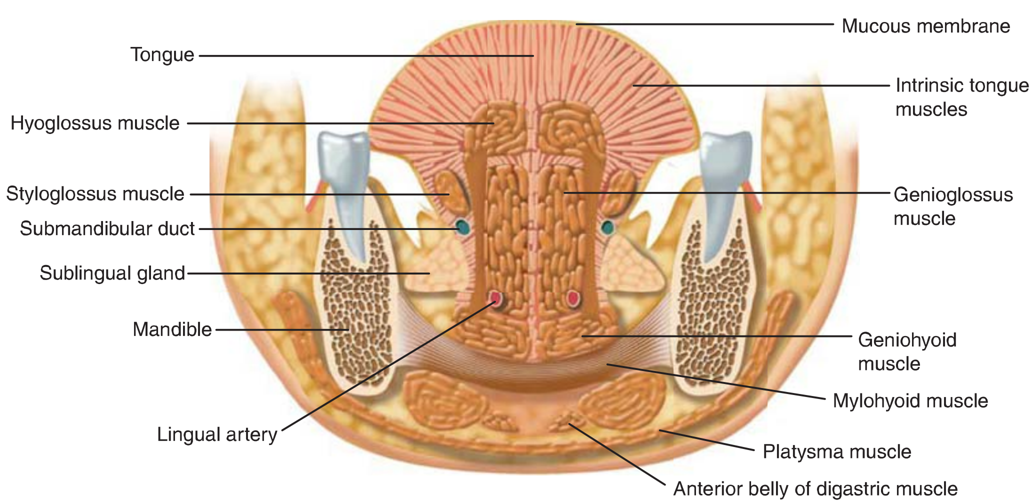

FIGURE 2.1
Coronal cross-sectional anatomy of FOM.

FIGURE 2.2
Patient positioning with nasal tracheal intubation and Gelfoam separating the tube from the nasal ala.

goal of providing a stable airway in the postoperative setting. In rare cases, an awake tracheostomy might be required for obstructing lesions. As with nasotracheal intubation, tracheostomy provides a secure operative airway with adequate visibility and work room for the planned surgical procedure. In complex cases involving free tissue transfer for reconstruction, care should be taken to ensure that the tracheostomy incision does not communicate with the neck incision since tracheal secretions could potentially bathe the vascular pedicle, resulting in flap failure.

Second Primary Tumor Investigation

Once the airway is secured, the patient's eyes are temporarily taped shut and a head drape is placed in preparation for an examination under anesthesia to search for a second primary cancer. This consists of a complete reassessment of the primary tumor and triple endoscopy (direct laryngoscopy, esophagoscopy, and bronchoscopy). In the case of an outside biopsy providing the tissue diagnosis, fresh tissue can be obtained to confirm the primary tissue diagnosis prior to surgical excision if needed. Any suspicious lesions found during the triple endoscopy are biopsied and evaluated by frozen section analysis prior to deciding whether to move forward with the planned procedure.

Positioning and Draping

Once a decision has been made to move forward with the planned procedure, sterile lubricating ointment is placed in both eyes and the eyes are taped shut using a clear Tegaderm. A thyroid bag or neck roll is used to extend the neck, and in the case of nasotracheal intubation, a pad of gauze is used to support the nasotracheal tube extending over the patient's forehead, followed by tape to secure it (Fig. 2.2). The patient is then prepped for the procedure. A sterile head drape is applied, leaving the oral cavity exposed. If bilateral neck exposure is needed, they should be secured in a manner that allows sterile rotation to either side to facilitate subsequent neck dissections.

Transoral Approach

Small lesions of the FOM, including early squamous cell carcinomas, can usually be effectively treated with a transoral approach. This approach provides adequate visualization for the surgeon to resect the lesion with adequate tissue margins (Fig. 2.3A). A self-retaining mouth retractor should be placed for exposure and a 2-0 silk suture used to retract the tongue. Mucosal incisions are made using electrocautery with a shielded Colorado Needle tip (Stryker-Leibinger, Freiburg, Germany) set on 20 W. A minimum of a 1-cm mucosal margin should be sought. The regular electrocautery shielded blade is then placed, and the underlying soft tissues are mobilized and divided. In the rare event that neck dissections are not planned, great care needs to be used to avoid injury to either the lingual nerve or hypoglossal nerves. Consequently, bipolar electrocautery is used in the vicinity of the hypoglossal and lingual nerves. Planned muscle margins should be at least 1 cm including the critical deep margin. It is not unusual in these cases for the sublingual salivary glands to form the deep margin of the surgical specimen. For superficial lesions, sparing the genioglossus muscle attachments to the genial tuberosity will minimize the impact on postoperative function of the tongue. The specimen should be marked for orientation prior to removal. To ensure accuracy the primary surgeon should accompany the frozen sections and orient the specimen for the pathologist. Adequate tumor clearance should be documented by frozen section analysis, and the pathologist should be encouraged to give estimates of the margins in millimeters from the tumor edge. If the primary cancer is small enough, the surgical defect could

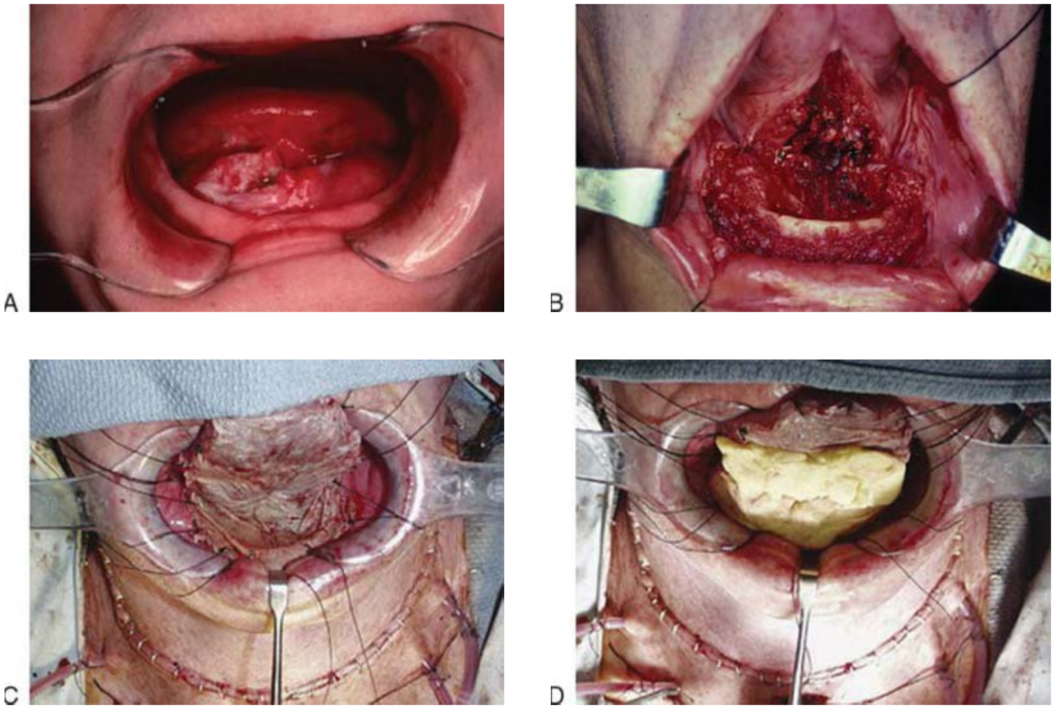

FIGURE 2.3 A: Squamous cell carcinoma of the FOM adjacent to alveolar ridge. **B:** Excision of cancer of the FOM. **C:** Split-thickness skin graft. **D:** Bolster used to stabilize skin graft. **E:** Skin graft healed.

be allowed to granulate and heal by secondary intention; however, if the depth of excision extends into the underlying musculature (Fig. 2.3B), granulation and healing by secondary intent often results in fibrosis and wound contracture, leading to impaired postoperative function. In these cases, coverage of the surgical defect by a skin graft is essential.

Removal of lesions of the FOM with an adequate margin often requires the sacrifice of one or both of Wharton ducts. There are two approaches to manage the submandibular duct. It can either be reimplanted posteriorly or laterally or it can be ligated and resected as part of the level I neck dissection. Since all but the most superficial squamous cell carcinoma will require neck dissection, the actual number of cases that will require duct transposition is small. If Wharton ducts are to be transposed, the surgeon should use a scalpel rather than electrocautery and make an oblique transection to provide a larger circumference at their opening to minimize subsequent risk of stenosis. A 4-0 chromic suture is used to marsupialize the posterior half of the circumference of the duct to the mucosa of the remaining FOM so that the duct will remain patent. In the case of skin graft reconstruction, the graft would be appropriately trimmed and sutured to the mucosal edges of the surgical defect using 3-0 chromic suture followed by approximation of the anterior half of the transected Wharton ducts to the skin graft with a 4-0 chromic suture. Stenting of the duct opening is not required. When a skin graft is used for reconstruction, it should be secured with 3-0 chromic suture and several incisions should be made to permit drainage of blood. Prior to placing the skin graft, meticulous hemostasis should be obtained, and a Valsalva performed to ensure adequate hemostasis and to prevent subsequent hematoma and graft failure. A Xeroform bolster is then anchored in place with 2-0 silk suture ties (Fig. 2.3C and D). A flexible small-caliber nasogastric tube is placed to maintain nutrition in the postoperative period. The bolster should be left in place for a minimum of 5 to 7 days and, if the patient can tolerate it, sometimes as long as 10 days to maximize graft take. The patient is kept NPO during this time period, and oral irrigations are used to maintain oral hygiene. The skin graft usually contracts a bit but is a good technique to resurface the FOM (Fig. 2.3E).

Marginal Mandibulectomy with FOM Resection

Patients with FOM squamous cell carcinoma up against or adherent to the lingual periosteum or over the alveolar process and onto the gingival surface without invasion are candidates for marginal mandibulectomy. Marginal mandibulectomy is contraindicated if there is extension from the alveolar process to the cancellous mandible, or direct tumor infiltration into lingual or buccal cortex of the mandible. Marginal mandibulectomy may also be contraindicated in the elderly or edentulous patient with inadequate mandible height due to the risk of subsequent fracture and in those patients who have received radiation therapy to the oral cavity. In these cases, a segmental resection in continuity with the FOM cancer is required. For advanced lesions that require a marginal mandibulectomy in continuity with the FOM resection, the patient will require a tracheostomy. The surgical approach in this case often consists of a transoral resection combined with a bilateral neck dissection incision allowing adequate exposure of the submental area or an anterior visor flap depending on the extent of the cancer and involvement of the anterior mandible. In the case of anterior alveolar process involvement by a FOM squamous cell carcinoma, the procedure can usually be safely performed through a transoral incision (Fig. 2.4A). Once the margins are defined, mucosal incisions are made over the mandible, dental extractions at the site of the proposed osteotomies are made, and the marginal mandibulectomy is performed using a handheld sagittal saw (Fig. 2.4B). In some cases, to provide an adequate margin while preserving mandibular height, an oblique osteotomy preserving more buccal than lingual mandible can be used. The tumor adjacent or adherent to the inner mandible is left intact for an en bloc oncologic resection. Depending on the location of the cancer, it is not unusual for the genioglossus muscle attachments to the genial tuberosity to be resected, although they should be spared if it does not compromise the oncologic resection. Adequate normal saline irrigation should be used during mandible resection to keep the underlying retained bone free from thermal injury and to maintain a clear operative field while the saw is being used. The nursing staff needs to keep accurate records of irrigation fluids to avoid erroneous estimates of intraoperative blood loss that could complicate postoperative management. Great care should be used during this portion of the procedure to protect healthy tissue such as the lips from inadvertent injury from the saw blade. Both the surgeon and assistant should be double gloved for this portion of the procedure and wearing approved eye protection to prevent biohazard exposure. Critical to the success of the marginal mandibulectomy is to perform a smooth rounded resection and avoid sharp angles that may lead to points of excessive stress and potential postoperative fracture. Use of a drill with a large cutting burr after the resection can round off any residual sharp edges of the mandible that may be bothersome in the postoperative setting, or interfere with the subsequent reconstructive effort. For advanced lesions, where bilateral neck dissections will be necessary, they should be performed prior to addressing the primary lesion so that the lingual and hypoglossal nerves have been identified and their location relative to the planned primary resection defined. This should minimize the likelihood of inadvertent injury. In those cases requiring nerve sacrifice due to direct cancer involvement, frozen section analysis should be used to obtain clear margins on the nerve due to the propensity of some tumors to have perineural spread. Reconstruction of the resulting defect requires the application of a split-thickness skin graft over the exposed mandible or a radial forearm free flap depending upon the size of the defect. Critical to the success of any reconstruction is to leave the lingual and labial sulcus intact after reconstruction to allow subsequent denture placement.

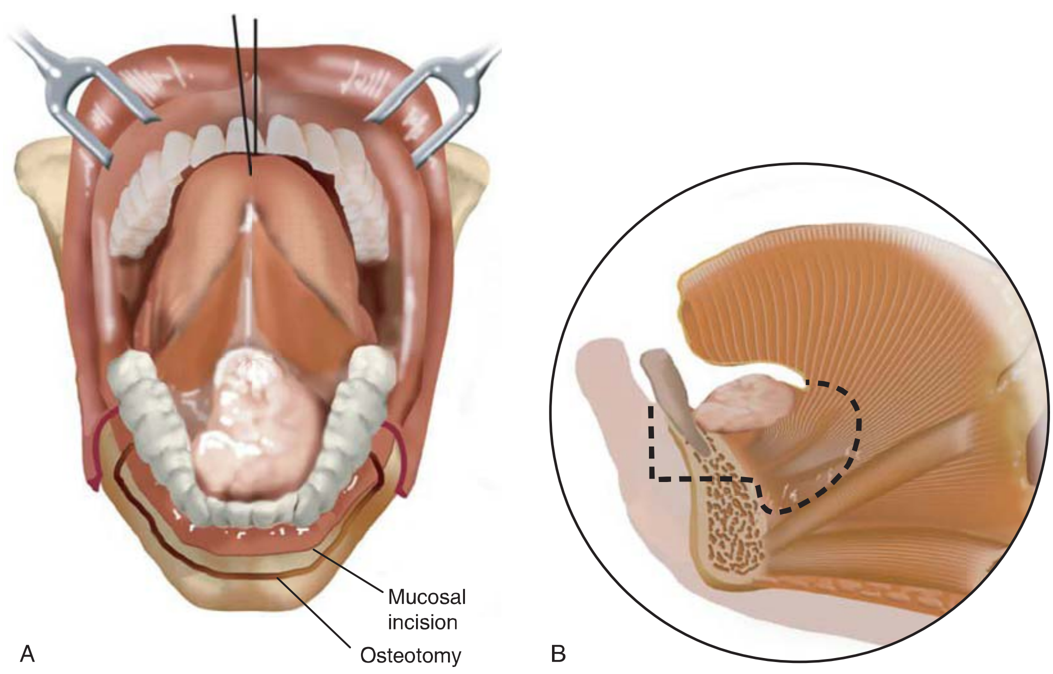

FIGURE 2.4
Marginal mandibulectomy with resection of the FOM. **A:** Trans-oral view. **B:** Sagittal view

Segmental Mandibulectomy with Resection of the FOM

In the case of more advanced lesions requiring anterior segmental mandibulectomy in continuity with the FOM, all patients will require preoperative tracheostomy. The surgical approach in this case usually consists of a bilateral visor flap to expose the anterior mandible and allow neck dissections to be performed (Fig. 2.5A). Here the skin incision extends from one mastoid tip to the other though a superior skin crease. Some surgeons will bring the incision forward toward the submental region to ease flap elevation. Great care should be taken to avoid injury to the marginal mandibular nerves bilaterally during flap elevation. The Colorado tip electrocautery is then used to incise the mucosa overlying the anterior lateral mandible as a gingivobuccal and gingivolabial incision. While this approach avoids the cosmetic impact of a midline split of the lip and chin, the need to divide all soft tissue lateral to the anterior mandible using the gingivobuccal and gingivolabial incision results in transection of the mental nerves with consequent anesthesia of the chin and lower lip bilaterally. As an alternate approach, the skin of the chin and central lip can be split down to the level of the mandible, allowing the mental nerve to be preserved for a small anterior segmental mandibulectomy, although the cosmetic result can be inferior. Different approaches to the lip and chin incision to maximize the cosmetic result are not widely agreed upon although a vertical straight line from the vermilion border to the submental crease to avoid contracture is an acceptable approach (Fig. 2.5B). In the case of a visor flap, once it is pulled over the mandible it is retracted and secured with several 1-inch Penrose drains rather than stay sutures to avoid excessive traction. Subplatysmal skin flaps are raised, and standard bilateral neck dissections are then performed. During this portion of the procedure, the hypoglossal and lingual nerves and lingual artery are identified and traced back towards the primary site. Donor vessels for free flap reconstruction are also isolated at this time and often consist of the facial artery and external jugular vein. The marginal mandibular nerves are identified bilaterally and elevated beyond the edge of the inferior mandible to protect them from injury. Mucosal incisions within the oral cavity with 1-cm margins are made as described during the transoral approach using the Colorado tip electrocautery. Cancer adherent to or invading the anterior mandible is left attached for an en bloc oncologic resection. The deep FOM musculature is divided as described earlier using electrocautery or bipolar as needed. If required, the attachment of the anterior belly of the digastric muscle to the mandible is then divided using electrocautery. The two mandibulotomy sites are noted, and electrocautery is used to mark the gingival mucosa down to the level of the mandible. At least 1.5 cm of bone should be excised on either side of the tumor. In the case of vascularized bone graft reconstruction such as a fibula free flap, additional soft tissue is cleared off the inferior aspect of the mandible for the placement of a temporary intraoperative external fixation device to maintain the proper alignment of mandibular segments without the use of a bridging reconstructive plate. This approach maintains proper dental and jaw alignment during the procedure. The external fixator is then removed but left assembled for later use during the reconstruction. Dental extractions are then performed at the site of the planned mandibulotomies to avoid possible tooth root exposure and loss. The sagittal saw is then used to divide the mandible at the designated gap. To prevent injury to underlying soft tissue, a malleable retractor can

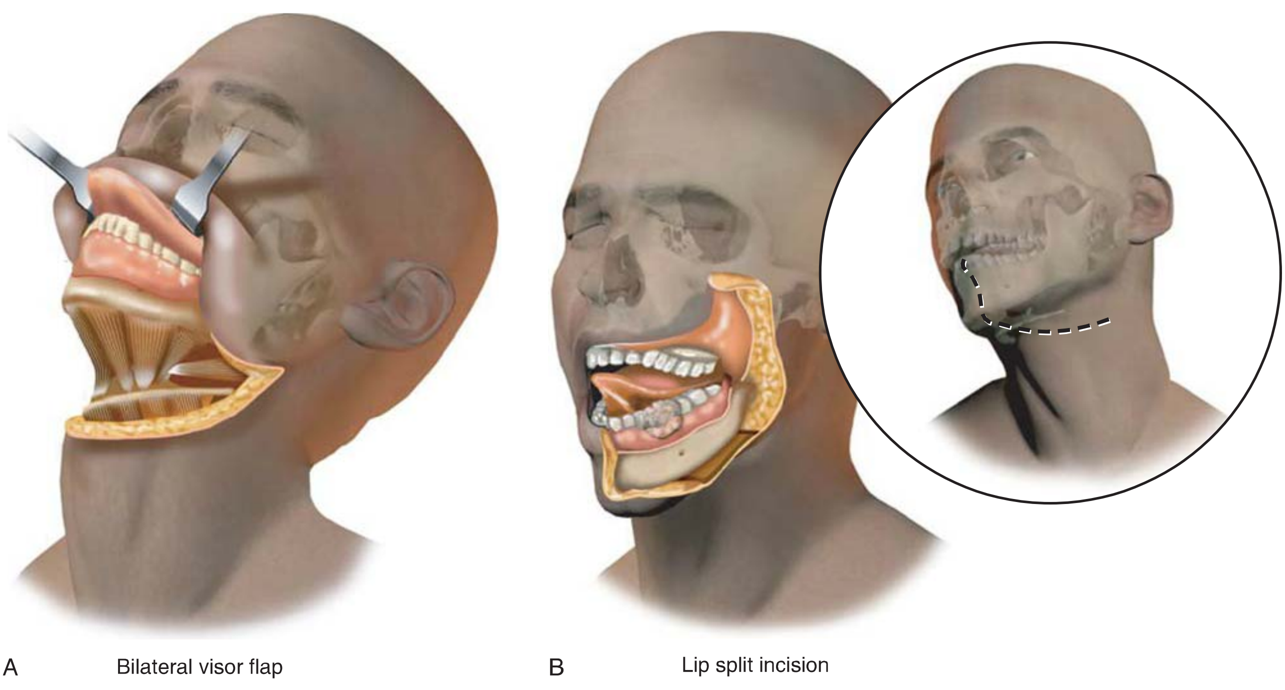

FIGURE 2.5 Surgical approaches to expose the mandible for advanced lesions of the FOM. **A:** Bilateral visor flap. **B:** Midline lip split incision.

be placed inferior to the mandibulotomy site while sawing. Hemorrhage from the cut ends of the mandible can be brisk and can be controlled with either bone wax or bipolar electrocautery. The ends of the mandible should then be inspected for tumor involvement, and if grossly clear, a bone marrow curette should be sent for frozen section analysis from the two cut mandible edges. Any remaining soft tissue connections are divided using bipolar electrocautery, and the specimen is immediately oriented and marked before being delivered to the pathologist who is oriented by the surgeon.

POSTOPERATIVE CARE

Patients with benign lesions or small transoral resections for early cancer that are either closed primarily or allowed to granulate can often be observed overnight to ensure that no edema or swelling develops and discharged the next day on a soft diet with oral rinses for hygiene, antibiotics, and pain medication. More extensive resections that required skin graft reconstruction and bolster placement or vascularized bone free tissue transfer will have a tracheostomy and require a small-caliber flexible nasogastric tube for nutrition during the healing process. Standard tube feed protocols and tracheostomy care should be instituted on these patients with airway monitoring. In these cases, the bolster over the skin graft should be left undisturbed for a minimum of 5 to 7 days, and if the patient can tolerate it, additional improvement in graft take is helped by keeping the bolster in place over the graft for 10 days. In those patients who had a small transoral excision, if postoperative swelling is minimal and the airway adequate, the patient's tracheostomy can often be downsized and capped and the patient discharged home with the bolster in place on nasogastric tube feeding. In the case of more extensive resections involving the mandible, vascularized bone free flap reconstruction and neck dissections, the patient will require suction drains for the necks and specialized care for monitoring of the flap and the donor site, in addition to tracheostomy care and nasogastric tube feeds.

COMPLICATIONS

Complications from FOM surgery are not unusual. Although most of these are relatively minor, the potential for more extensive complications is substantial especially considering that the surgery for these cancers can range from simple transoral excision to radical ablations involving the deep tongue musculature and/or mandible that require complex reconstructive procedures. In addition to the complications that are common to almost all surgical procedures of the head and neck, some are unique to the FOM region, and the potential impact of complications on speech and swallowing function are of critical importance.

Wound Infection

Probably the most common complication seen after oral cavity surgery is wound infection, with the rate of wound infections certainly being higher when composite resections are performed. Avoidance of serious wound infections is essential to prevent the loss of reconstructive tissue and possible subsequent fistula formation. Many different factors may contribute to wound infections after FOM surgery, but like all wound infections after surgery, they can be categorized into patient-related and technical risk factors. Patient-specific factors include nutritional status, prior history of preoperative radiation therapy, poor dental hygiene, and significant medical problems. All of these factors may potentially play a role and may influence the rate of wound infection. With regard to specific medical problems, diabetes mellitus is a well-recognized risk factor and associated with increased rate of wound infections, and proper blood sugar control in the perioperative period is imperative. Meticulous surgical technique to ensure hemostasis; appropriate drain placement; and tension-free, watertight closures will all contribute to a decreased frequency of postoperative infection. Perioperative antibiotics should cover both aerobic and anaerobic bacteria and be maintained until the bolsters and drains are removed.

Fistula

Oral cutaneous fistula is also a significant complication from FOM surgery. These fistulas result in considerable morbidity for the patient. These do not occur when a simple transoral approach is performed and are more likely to be seen when wide local excisions for more advanced lesions are performed with coincidental neck dissection. Risk factors for fistula formation include wound infection, prior history of radiation therapy, and wound dehiscence secondary to suture line failure or failure of the flap reconstruction. Certainly close attention to surgical technique and perioperative antibiotic coverage can minimize the likelihood of this complication, as can the presence of healthy and viable reconstructive tissue. In those cases where a fistula has developed, the wound should be opened to direct the fistulous tract away from the carotid artery and vascular pedicle of the reconstructive flap if viable. In addition, any necrotic tissue should be debrided, the wound should be cultured, and aggressive oral hygiene and local wound care instituted. Antibiotic coverage should be guided by cultures and sensitivities. Most fistulas will respond to conservative management; however, some

may require an additional reconstructive procedure to bring in fresh vascularized tissue to allow closure. The ablative surgeon and reconstructive surgeons should make an all-out effort to prevent any delays in subsequent radiation therapy when planned.

Nerve Injury

Both the lingual and inferior alveolar nerves are at particular risk in surgical procedures of the FOM. The sensation of the oral cavity and lower lip is derived from branches of the mandibular division of the trigeminal nerve. Consequently, nerve injury and loss of sensation can lead to a loss of oral competence and subsequent drooling, as well as difficulties with speech and swallowing. There can also be difficulties in the setting of loss of sensation in the tongue or lip resulting in subsequent bite trauma. The marginal mandibular nerve of the facial nerve can also be injured both during the neck flap elevation and in a visor flap approach to the FOM. In this case, loss of depressor function gives the well-known cosmetic deformity of lower lip position and may contribute to drooling and loss of oral competence. Finally, injury to the hypoglossal nerve with subsequent paresis due to immobility of the ipsilateral tongue will have a significant impact on speech and swallowing function.

Lesser complications from FOM resections include hematoma, which can often be prevented by meticulous operative technique as well as by the appropriate use of a bolster in the setting of skin graft reconstruction. Other complications include injury to Wharton duct with duct stenosis and subsequent submandibular gland sialadenitis and infection. Stenosis of the duct opening can also occur with similar sequelae due to inadequate suturing at the time of transposition. Loss of the skin graft with subsequent wound contracture can lead to tongue tethering and have a negative impact in both speech and swallowing function.

RESULTS

Surgical therapy of FOM squamous cell carcinoma is an effective therapeutic modality either as a single modality or followed by adjuvant radiation therapy. Significant survival advantages can be seen in patients with clear resection margins, early T stage, and a lack of cervical lymph node metastases. The ablative surgeon should make an all-out effort to obtain clear resection margins including the use of frozen sections at the time of the initial surgery. If close or positive margins are found on permanent sections, repeat resection is recommended if feasible due to the documented inability of postoperative radiation to significantly alter survival in patients who have a positive margin. The high recurrence rates and propensity to develop second primary cancers necessitates regular monitoring as recommended by the NCCN guidelines.

PEARLS

- The majority of cancer of the FOM can be diagnosed safely using an office incisional biopsy followed by silver nitrate cauterization.
- Neck dissections are recommended when the depth of invasion is 3 mm or greater.
- A neck roll will enhance exposure when positioning the patient for the procedure.
- Extreme care needs to be used to preserve the lingual nerve if the sublingual gland is removed as the deep margin.
- Identification and preservation of the lingual and hypoglossal nerves as well as the lingual artery can be facilitated by performing the neck dissection prior to the oral resection.
- Dental extractions should be done at the time of the ablative surgery.
- During nasotracheal intubation, ensure that after prepping and draping, the nasal ala is adequately protected and visible to allow monitoring during the procedure.
- Intraoperative margin analysis can be very demanding and requires close cooperation between the ablative surgeon and the pathologist. To avoid the frustration of negative frozen section margins from the surgical bed being confounded by a subsequent close or positive margin on the surgical specimen, ask the pathologist to perform a sagittal section through the deepest portion of the lesion to examine the deep margin on the surgical specimen at the time of surgery.
- The majority of patients reconstructed with a split-thickness skin graft and retaining bolster will require a tracheostomy.
- When assessing the edentulous patient for possible marginal mandibulectomy, careful consideration needs to be given to the height (vertical dimension) and thickness of the mandible to ensure they are adequate to avoid postoperative fracture. If needed, mandible plating can be performed to strengthen the area.
- Prior history of radiation is a contraindication to marginal mandibulectomy.
- When determining possible mandible invasion and the need for marginal mandibulectomy, use the Colorado tip electrocautery to incise the mucosa over the lingual cortex, and try to elevate the periosteum over the bone using a Freer elevator. Perform this step early in the operation in case an unplanned need for segmental mandibulotomy is identified.

- Use a Dobhoff silicon nasogastric feeding tube for patient comfort if enteral nutrition will be administered.
- Free flap reconstruction rather than a skin graft should be used in patients with a prior history of radiation therapy to prevent skin graft failure, exposed mandible, and subsequent osteoradionecrosis.

PITFALLS

- Inadvertent injury to the lingual nerve resulting in postoperative trauma to the tongue from anesthesia
- Inadvertent injury to the hypoglossal nerve resulting in postoperative tongue hemiparesis
- Inadequate hemostasis after the ablative resection will result in the need for emergent airway management or reconstructive failure due to hematoma.
- Fracture of the mandible due to inadequate residual bone after marginal mandibulectomy or inappropriate osteotomies prone to fracture
- Late intraoperative identification of invasion of the mandible can result in the need for an unplanned segmental mandibulectomy.

INSTRUMENTS TO HAVE AVAILABLE

- Sluder-Jansen mouth gags
- Spandex lip and cheek retractors
- Stryker-Leibinger Shielded Colorado needle tip

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3 EXCISION OF CANCER OF THE BUCCAL MUCOSA

Anil K. D'Cruz

INTRODUCTION

Cancers of the buccal mucosa are a global problem. The incidence varies from 40% to 60% of all cancers of the head and neck in South Asia to about 10% in North America and Western Europe. The main reason for this disparity is the use of smokeless tobacco in South Asia. Quid (paan), which is a combination of areca nut, slaked lime, and tobacco, is usually kept in the gingivobuccal sulcus for prolonged periods of time exposing the mucosa to multiple carcinogens.

Cancer of the buccal mucosa usually presents late and behaves more aggressively when compared to carcinomas of other subsites of the oral cavity due to the limited anatomic barriers within the buccal space. A high rate of locoregional recurrence (26% to 80%) after treatment is the most common cause of mortality in this group of patients. Surgery is the mainstay of treatment for these cancers and therefore needs to be planned accurately and executed appropriately to give the patient the best chance for cure.

HISTORY

Cancer of the buccal mucosa is associated with few symptoms in the early stages, and an accurate history is imperative to establish an early diagnosis. The most common presentation is a patch or a nonhealing ulcer in the oral cavity. Any such lesion, particularly in a tobacco/alcohol user, that persists more than 6 weeks warrants speciality consultation and investigation. In those without a history of addiction, a history of carious and sharp teeth should be sought. History of pain usually signifies deep infiltration of a locally advanced cancer. Recent onset of trismus is indicative of involvement of the infratemporal fossa, a sign of relative inoperability. This must be differentiated from a history of long-standing trismus, which may be associated with submucous fibrosis, a peculiar premalignant condition seen in patients in Southeast Asia who consume *Areca* nut (Fig. 3.1). Loosening of teeth is indicative of invasion of the adjacent alveolus. Patients who have advanced cancer may present with fullness in the region of the hemiface and erythema or ulceration of the skin.

PHYSICAL EXAMINATION

Lesions must be carefully examined to help in accurate surgical planning. The location of the cancer in relation to the commissure anteriorly, retromolar trigone posteriorly, upper alveolus superiorly, and lower alveolus inferiorly must be assessed both visually and by digital palpation. Very often, contiguous bone involvement can be suspected clinically even before imaging. The skin overlying the ulcer must be examined for puckering, tethering, or frank invasion. Cancer of the buccal mucosa may be associated with a coexisting premalignant condition, and the entire oral cavity must be carefully inspected.

FIGURE 3.1
Oral submucous fibrosis with trismus.

Occasionally in patients who have severe pain and trismus, examination may need to be performed under a brief general anesthesia. Inadequate mouth opening (pseudotrismus due to pain and masseter spasm) may be relieved after the administration of general anesthesia. This facilitates proper evaluation of the extent of the lesion in the oral cavity.

Cancer of the buccal mucosa has a lower propensity to metastasize to the cervical lymph nodes when compared to cancer of the tongue. The first echelon of nodal spread is usually Level I (submental and submandibular). The entire neck must be carefully examined for metastatic lymph adenopathy.

Two additional areas of particular importance that must always be examined are soft tissue involvement by tumor in the paramandibular region and its relationship to the zygoma superiorly. For paramandibular spread of the tumor, involved soft tissues are checked for mobility with relationship to the mandible by palpating the cheek from the exterior (Fig. 3.2). In those cancers that do not move freely on the mandible, a marginal mandibulectomy may not be feasible even if bone is not radiologically eroded on imaging. If induration extends superiorly to the zygoma, achieving negative margins is difficult and the patient should be considered inoperable. It is a good clinical practice to use bimanual palpation to assess the superior extent of the cancer.

Careful examination of the dentition is critical to look for dental caries, periodontal disease, and fractured sharp teeth. Hypoesthesia in the region of the chin is suggestive of involvement of the inferior alveolar nerve.

Lastly, as in all cancers of the head and neck, a thorough endoscopic examination of the entire upper aerodigestive tract is warranted to look for synchronous second primary cancers.

INDICATIONS

Surgery is the mainstay of treatment for cancer of the buccal mucosa, and all operable lesions should be considered for excision if the patient is fit for general anesthesia. The indications for surgery would therefore be all lesions clinically staged T1 to T4a.

FIGURE 3.2
Mobility of soft tissue over the mandible is checked in the presence of paramandibular spread to assess for feasibility of marginal mandibulectomy.

The extent and approach for excision would vary depending on the clinical T stage. Lesions should therefore be assessed for suitability of approach (per oral or via cheek flap) and for the need of excision of adjoining mandible (marginal or segmental mandibulectomy).

Early superficial accessible midbuccal lesions are approached perorally. A cheek flap approach is necessary in patients with restricted mouth opening (trismus), lesions located posteriorly, in larger tumors and those requiring mandibulectomy.

If the lesion abuts or is superficially eroding the mandible, a marginal mandibulectomy is advisable. Advanced lesions with gross invasion of the mandible or lesions with significant paramandibular spread require segmental mandibulectomy for oncologic adequacy. The specific indications and contraindications to various surgical approaches are discussed in respective sections.

CONTRAINDICATIONS

Contraindications to surgery can be divided broadly into two groups: those associated with fitness for surgery and those with advanced cancer factors. Cardiovascular disease, pulmonary disease, compromised renal function, and uncontrolled diabetes that render the patient unfit for general anesthesia preclude surgery. Locally advanced cancers staged T4b are contraindications to surgery, namely, involvement of the masticator space (Fig. 3.3), destruction of the pterygoid plate, involvement of the skull base, and cancer encasing the internal carotid artery. Extensive involvement of skin and soft tissue is also a contraindication to surgery. These include induration extending to the zygoma, diffuse edema of the hemiface, and multiple skin nodules.

Involvement of the infratemporal fossa was traditionally considered a sign of inoperability. However, recent evidence suggests that involvement of the infratemporal fossa into the notch (cancer inferior to the sigmoid notch) may be amenable to surgery with reasonable possibility of control. In a study conducted by Liao et al., the disease-free survival in infranotch and supranotch T4b cancers of the oral cavity was 64.7% and 14.3%, respectively, with overall survival of 55.3% and 14.3%, respectively (Figs. 3.4 and 3.5).

PREOPERATIVE PLANNING

Imaging

Imaging should be performed in all cases of cancer of the buccal mucosa as it provides valuable information with regard to extent of the cancer. The only exception would be in very early superficial cancers with a clinically node-negative neck where peroral excision is planned. Ultrasound examination of the neck is all that needs to be done to identify subclinical nodal metastasis if observation of the neck is contemplated.

FIGURE 3.3 Coronal 16-slice contrast enhanced computed tomography (CECT) reformation defining the boundary of the masticator space (enclosed by the *white line* that represents slips of the investing layer of cervical fascia). (*m*, masseter muscle; *asterisk*, lateral pterygoid muscle; *short arrow*, medial pterygoid muscle.)

FIGURE 3.4
A: Axial CECT at the level of the mandibular notch; *thick arrow* shows coronoid process; *thin arrow* shows condyle. **B:** Modified oblique reformation on 16-slice CT (bone window) shows *black line* demarcating supra- and infranotch levels (high and low infratemporal fossa).

CT and MRI scans both have their advantages and are complementary to each other. CT scan is usually preferred as the initial imaging modality as it is easily available, less expensive, and preferred by most surgeons for interpretation. It gives a fair idea about the extent of the lesion, involvement of the cortical bone, and extension into the infratemporal fossa. MRI is better for the evaluation of recurrent cancer and involvement of medullary bone. Accurate assessment of the depth of infiltration and early involvement of the periosteum are sometimes hindered due to the apposition of mucosal surfaces of the buccal cavity. The puffed cheek technique described by Weissman and Carrau is a useful maneuver in such situations. In this technique the patient blows uniformly through the pursed lips, which opens up the buccal vestibule while the CT is being performed. This helps to assess the surface of the mucosa that is normally apposed, namely, the cheeks, gingiva, lips, and buccal vestibule. It also helps to predict the extension of the cancer into the buccinator space and retromolar trigone (Fig. 3.6).

The role of the orthopantomogram in assessing contiguous mandibular involvement has diminished with the advent of the CT scan. This is primarily because of a low sensitivity (60% to 64%), high false-positive rates, inability to identify early erosion, and limitation in the region of the middle third of the mandible.

Biopsy

Histopathologic confirmation of malignancy is mandatory and is best established by punch biopsy. This can be performed in the outpatient clinic using a 3- to 5-mm biopsy forceps. Biopsy is targeted from the most representative area avoiding obviously necrotic areas within the lesion. On occasion where punch biopsy is not

FIGURE 3.5
Coronal CECT reformation demonstrating spread of the cancer into the superior aspect of the infratemporal fossa into the superior aspect of the buccal mucosa (*arrow*).

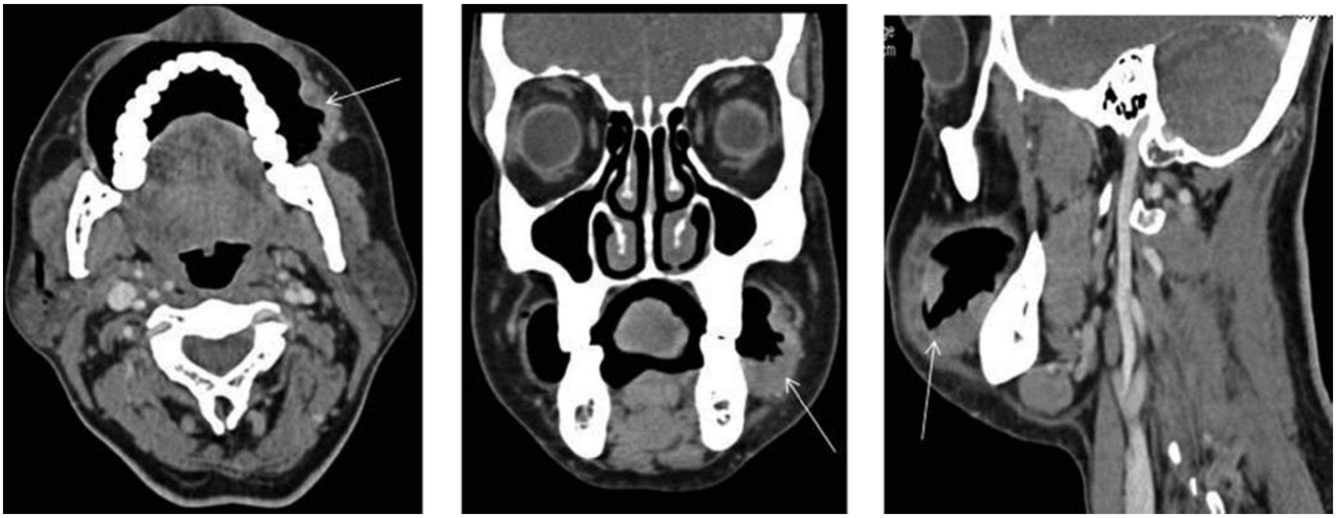

FIGURE 3.6 Axial, coronal, and sagittal CT scan obtained with the puffed cheek technique shows enhancing left buccal buccinator complex mass with involvement of gingivobuccal mucosa (tumor marked by an *arrow*).

feasible (submucosal tumor), an incisional knife biopsy should be performed under local anesthesia. Scrape cytology is not reliable in oral lesions. Whenever clinical suspicion is high and scrape cytology negative, an incisional biopsy is indicated.

Dental Prophylaxis

Appropriate treatment should be given in the form of scaling, attention to infectious foci, periodontal disease, and tooth extractions when indicated. This is all the more important if there are plans for adjuvant radiotherapy. Radiotherapy results in xerostomia with impaired oral hygiene. Any subsequent manipulation of the teeth after completion of the radiotherapy predisposes toward osteoradionecrosis of the mandible.

Plastic Reconstructive Consultation

The majority of patients undergoing excision of cancer of the buccal mucosa require postexcision reconstruction. Consultation with a plastic reconstructive surgeon prior to surgery helps in appropriate planning and counseling the patient.

SURGICAL TECHNIQUE

Cancer of the buccal mucosa can be excised either perorally or through a cheek flap approach. The aim at surgery is adequate exposure of the lesion to ensure complete three-dimensional clearance of the cancer. Anterior lesions, not deeply infiltrative, and well visualized in their entirety, are suitable for peroral excision. Posterior, deeply infiltrative cancers close to upper and lower alveolus and those not well visualized in their entirety should be excised by the cheek flap approach. The neck, if addressed, is either through a separate incision (if cancer is excised perorally) or in continuity when a cheek flap is used (Fig. 3.7).

Peroral Wide Excision

Prerequisites

- Early superficial cancer
- Anterior location to midbuccal
- Adequate mouth opening
- Adequate visualization and accessibility of the cancer to ensure appropriate three-dimensional clearance

General anesthesia and nasotracheal intubation are preferred. Excision under local anesthesia may seem tempting in excising small cancers but may result in compromised margins if the patient is uncooperative. The safety of the airway is secured via a throat pack. The patient is prepared and draped, and the head end of the table is raised 10 to 15 degrees which reduces venous congestion and decreases bleeding. A mouth gag is

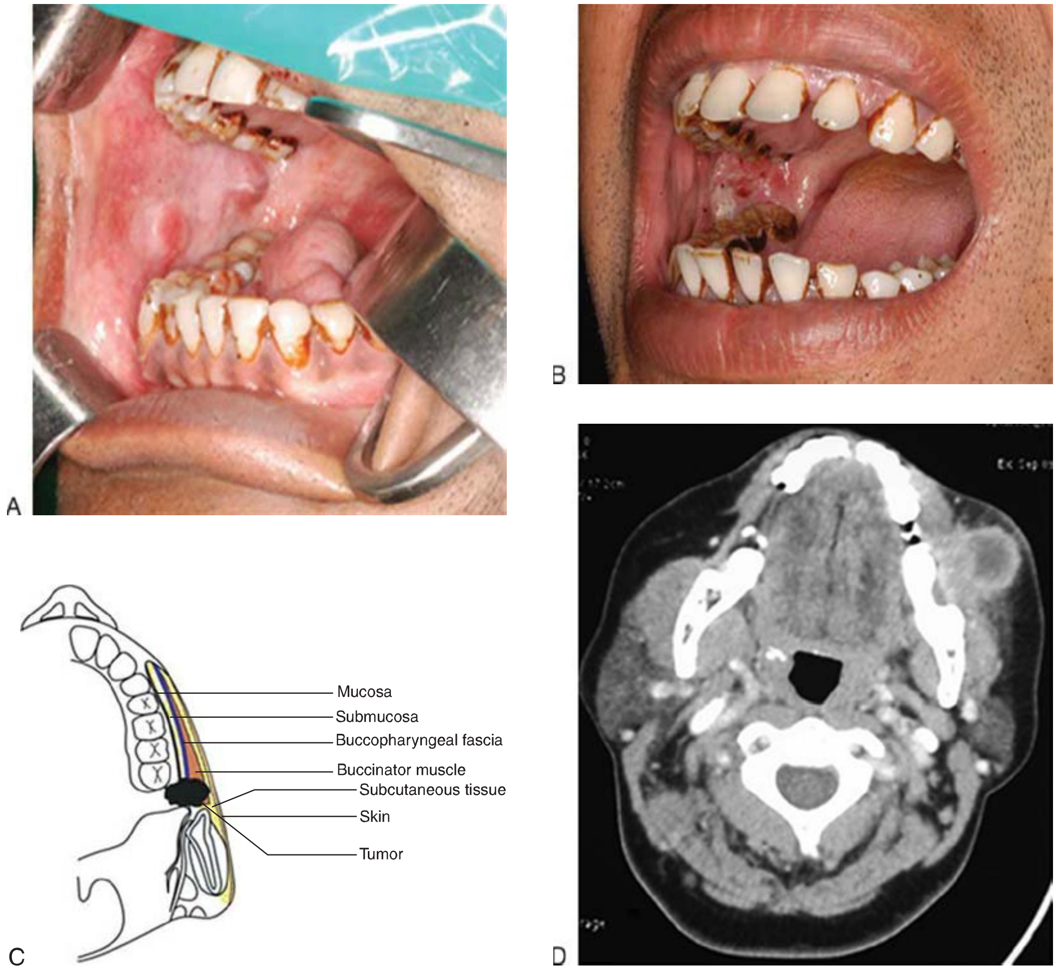

FIGURE 3.7
A: Peroral approach. Anterior location, tumor well visualized in its entirety. **B:** Cheek flap approach should be used to excise this. Cancer located posteriorly is not well visualized in its entirety. **C,D:** Deeply infiltrative lesion well approached via cheek flap.

applied and the lesion exposed. The margins of excision are outlined a minimum of a centimeter away from the palpable edge of the tumor. A minimum margin of 0.5 cm must be achieved in all dimensions (Figs. 3.8 and 3.9). Mucosal margins postexcision are known to shrink between 30% and 50%, and this must be considered when placing a mucosal incision. Mucosa, submucosa, and deeper tissues up to the desired depth are incised using electrocautery at the same level as was marked for the mucosal excision. A common error is to apply traction to the specimen and divide deeper tissues in oblique fashion compromising soft tissue margins. The depth of excision is determined by operative and prior radiographic findings. Excision of a superficial cancer is carried out

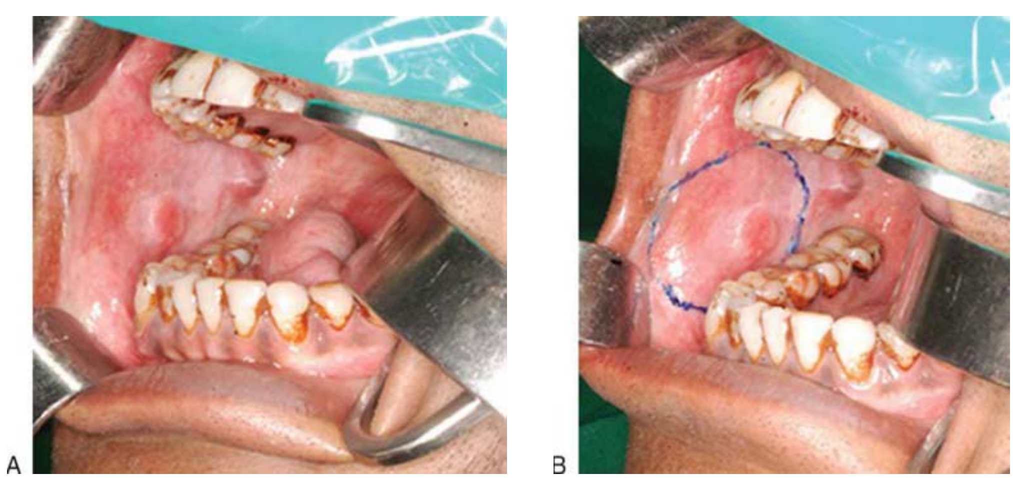

FIGURE 3.8
A,B: Peroral excision.

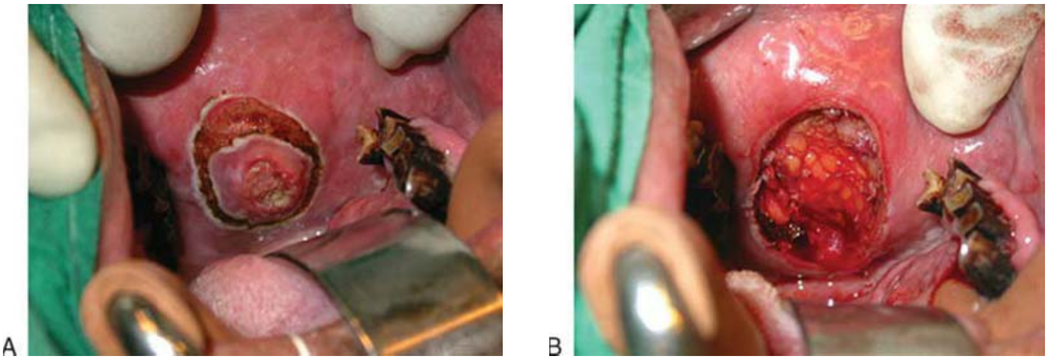

FIGURE 3.9
A,B: Lesion suitable for grafting.

down to the depth of the underlying buccinator muscle (Fig. 3.10). It is a safe practice to ligate the buccal branch of the facial artery at the margin of the surgical defect. This maneuver is important in preventing postoperative hemorrhage. Hemostasis is secured. The defect if small may be allowed to granulate and heal by second intention. However, defects following excision for cancer are usually of substantial proportion, and a reconstructive procedure is warranted. Midbuccal mucosa defects can be resurfaced using a split-thickness skin graft. Split-thickness skin graft is harvested from the medial aspect of the thigh. Multiple incisions are marked on the graft, and a Xeroform gauze bolster is applied using 2-0 silk tie over sutures. When the defect involves the majority of the buccal mucosa or is accompanied by the excision of the adjoining bone, a radial forearm flap is the preferred method of reconstruction. A dorsal tongue flap is also a useful alternative but has largely been discontinued since the advent of the free flap.

Alimentation is established using a nasogastric feeding tube. Meticulous oral hygiene is maintained postoperatively to prevent loss of the graft and secondary hemorrhage. The bolster is removed 5 days postoperatively, and oral feeding is encouraged. Jaw stretching exercises are initiated to prevent the development of trismus secondary to contraction of the skin graft.

Wide Excision Via Cheek Flap with Lip Split

The lower lip splitting incision provides good access for excision of cancers of the buccal mucosa. The anatomic considerations and principles of surgery should be adhered to while planning the incision, which may otherwise lead to troublesome sequelae such as unsightly notching of the vermilion, loss of chin pad, loss of chin sensation, reduced mobility of the lip, and incontinence of the oral commissure.

There are many modifications proposed for the lower lip split incision. The midline vertical or Roux Trotter incision is used most often. Several modifications have been proposed such as the McGregor (circumventing cutting through the chin pad), Rassekh (modified zigzag-stepped technique) (Fig. 3.11), the Hayter (integrating the chevrons in the vermilion area and mentolabial groove), and Ramon (stepped technique). These modifications have postulated benefits but may compromise soft tissue margins especially if the incision is located anteriorly. My preference is to perform a vertical midline incision as it is easy to perform and does not injure branches of the facial nerve. Similarly visor flaps without lip split have been described particularly when both sides of the neck are to be addressed. Using this approach is technically difficult, requires division of both the mental nerves, and may provide inadequate exposure of posteriorly based lesions.

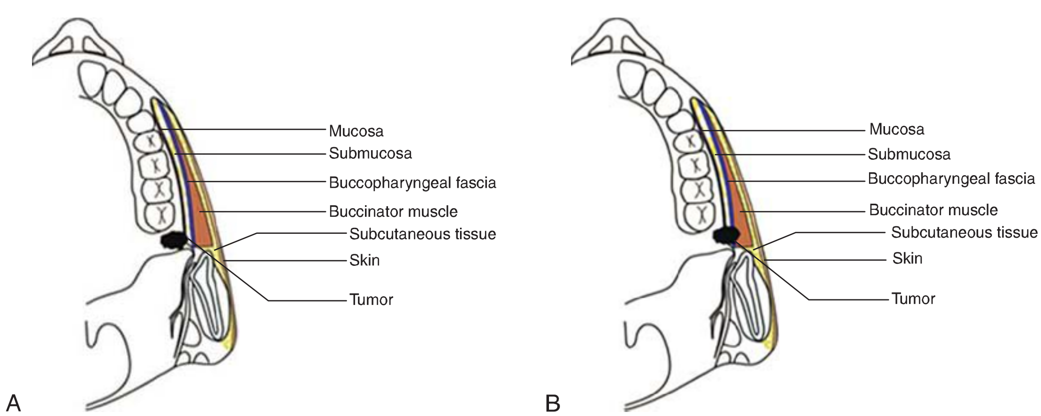

FIGURE 3.10
A: Tumor involving mucosa and submucosa. Requires skin grafting. **B:** Tumor invading the buccinator muscle requires a radial forearm flap reconstruction.

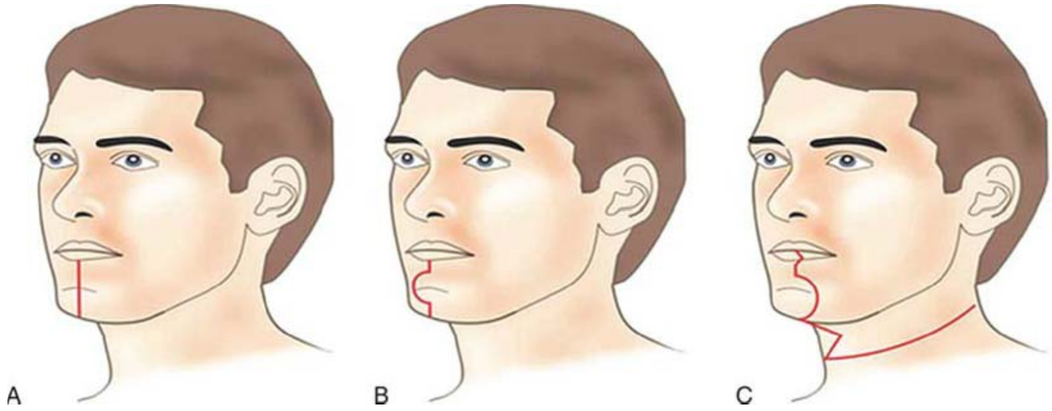

FIGURE 3.11
Lip-split incisions. **A:** Roux. **B:** McGregor. **C:** Rassekh—Modified zigzag.

INDICATIONS

- Cancers not accessible for excision via peroral approach
- Larger cancers—T2 and above
- Inadequate mouth opening
- Cancer not visualized in its entirety
- Posteriorly situated
- Cancer that requires resection of bone
- Deeply infiltrative cancers

Preparation of the patient is as per peroral excision as described earlier. The skin incision is planned usually with a midline lip split and extended inferiorly to be continuous with the skin crease incision for neck dissection. A saline adrenaline infusion in a dilution of 1 in 100,000 is helpful in avoiding troublesome bleeding from the skin edges. A lip split through the angle of the mouth rather than the midline may be necessitated if the cancer extends to within a centimeter of the commissure orally. The lip is supplied by the labial branch of the facial artery with the watershed area in the midline. The midline lip split incision in such cases compromises the blood supply to the lip and may lead to the necrosis of the segment of the lip and the adjoining skin (Fig. 3.12).

The skin is incised and deepened down to the dermis. Deeper dissection is done best using a monopolar cautery as this area is richly vascularized, and there may be troublesome oozing. Soft tissues are divided and deepened up to the reflected gingivolabial mucosa. A margin of 5 mm of reflected gingivolabial mucosa is left

FIGURE 3.12 **A:** Cancer 1 cm from the commissure. *Black arrow* points toward the labial artery. **B:** Angle-split incision. **C:** Midline split may lead to necrosis of intervening skin. *White arrow* points to watershed area.

attached to the mandible to aid closure. The cheek flap is elevated leaving soft tissue cover on the lateral cortex of the mandible if possible. The lesion is excised with adequate mucosal and soft tissue margins. Particular care is taken to ensure adequate clearance in the depth of the lesion. A good guide to ensure this is raising of the cheek flap in the subcutaneous plane. Subcutaneous adipose tissue is best recognized as being granular as opposed to the globular buccal pad of adipose tissue. It is advisable to have completed the neck dissection prior to excision of the buccal mucosa lesion. This facilitates raising of the cheek flap and minimizes blood loss as the facial artery has usually been ligated at the lower border of mandible. Hemostasis is secured following excision. The raw area defect is reconstructed using a split-thickness skin graft, tongue flap, or a radial forearm flap. The cheek flap is repositioned and sutured in layers. Particular attention is paid to reapproximate the lip with meticulous alignment of the vermilion border and closure in three layers (skin, muscle, and mucosa). This ensures prevention of notching and good postoperative oral competence. Feeding is established via nasogastric tube until healing is complete. Meticulous oral hygiene is maintained using oral rinses and gargles.

Wide Excision with Mandibular Resection

Cancer of the buccal mucosa may require resection of the adjoining alveolus to ensure adequate clearance. This may encompass superior alveolectomy, marginal mandibulectomy, or a segmental mandibulectomy. An adequate margin of bone minimum 5 mm must be ensured. Marginal and segmental mandibulectomy requires special consideration, and these are described below.

Marginal Mandibulectomy

Indications

- When primary cancer abuts the mandible
- Superficial cortical erosion of <0.5 cm

CONTRAINDICATIONS

- Cortical erosion more than 0.5 cm
- Gross invasion of the mandible medullary bone
- Involvement of the inferior alveolar nerve
- Postradiation recurrence
- Edentulous pipestem mandible
- Paramandibular spread

Marginal mandibulectomy can be performed perorally but is usually done via a cheek flap in majority of cases. The cancer is excised via a midline lip-splitting incision. Resection is completed except where the soft tissue is attached to the lateral cortex of the mandible. The mandible is exposed at the site of the proposed osteotomies ensuring adequate clearance of paramandibular soft tissue. The osteotomies are developed ensuring 0.5-to 1-cm margin on the bone. The resection of the bone must be performed in a smooth curvilinear fashion classically described as "canoe" shaped. Sharp right-angled osteotomies should be avoided as this may result in fracture of the mandible during mastication. A minimum of 1 cm in vertical height must be retained to ensure structural integrity (Fig. 3.13). The marginal mandibulectomy can be performed involving any segment of

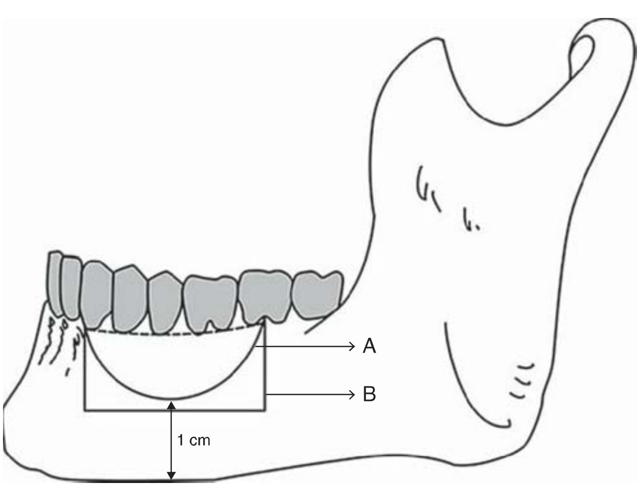

FIGURE 3.13 Technique of marginal mandibulectomy. **A:** Correct technique with canoe-shaped cuts. **B:** Incorrect technique with sharp right-angled osteotomies.

the mandible. However, for cancer situated posteriorly, the procedure becomes technically more challenging. Resection in these cases necessitates excision of part of the vertical ramus, including the condyle. Adequate soft tissue excision must be ensured particularly in the region of the retromolar trigone. Appropriate reconstruction of the defect is done using a skin graft, tongue flap, or radial forearm flap. Reconstruction using the tongue flap or the primary closure results in the obliteration of the sulcus. This may pose difficulty in applying a denture and hence has been largely abandoned.

Segmental Mandibulectomy

Segmental mandibulectomy may be posterior segmental, hemimandibulectomy, or arch-preserving mandibulectomy depending on the location of the cancer.

INDICATIONS

- Gross invasion of bone
- Invasion of the inferior alveolar nerve
- Invasion of the medullary canal
- Significant paramandibular spread
- Marginal mandibulectomy not feasible

The initial steps and preparations are as described before. If excision of overlying skin is necessary, it is a good practice to outline the skin markings first. Appropriate extensions are then made from these markings to gain entry intraorally and for neck dissection. Adequate mucosal and soft tissue clearance of tumor is performed. The mandible is exposed at the points of proposed resection. The osteotomies are made using a powered saw and specimen excised en bloc. Brisk hemorrhage following the osteotomies is controlled by applying bone wax. Whenever possible, as much of the ascending ramus and arch of the mandible should be preserved as this facilitates subsequent reconstruction and decreases functional and cosmetic morbidity. Reconstruction of the bone is usually performed using free fibula microvascular bone reconstruction. In extended mandibular and middle-third resections, it is safer to perform a tracheostomy for the immediate postoperative period. When margins of the bone resection are in doubt, the marrow from the cut ends of the mandible can be curetted and sent for frozen sections.

Neck Dissection

Appropriate neck dissection is performed accordingly at the time of the excision of the cancer of the buccal mucosa. The extent and levels of neck dissection are debatable, but the usual dictum is a modified neck dissection for node positive cases and supraomohyoid dissection for node negative cases.

POSTOPERATIVE MANAGEMENT

Maintaining good nutrition and oral hygiene and proper rehabilitation constitute the important components of postoperative management. Nasogastric feeding should be instituted as early as possible. Care should be taken that the patient has fully recovered from the effects of anesthesia with all reflexes normal to prevent against aspiration. I prefer to start with the test bolus feeds, and if tolerated this is gradually increased to full feeding. Good oral hygiene helps to prevent graft rejection and secondary hemorrhage as well as promoting early healing. Frequent mechanical cleansing is to be emphasized, which is more important than medicated mouth washes. The power spray is a good option, but if unavailable jet irrigation using a 20-mL syringe with the needle hub is a suitable alternative. In addition, patients are encouraged to gargle with medicated mouth rinses. Regular monitoring of the flap is necessary in patients who have undergone microvascular reconstruction. The initial 48 hours are the most important for survival of any flap. Flaps need to be monitored for change of color, capillary filling time, turgor, temperature, and dermal bleeding. The patient should be taught jaw stretching exercise to prevent against trismus, particularly if the skin graft has been used. Guide bite prosthesis is provided to prevent against the jaw deviation if the ipsilateral mandible is resected. Speech and swallowing rehabilitation is initiated once the patient is ready for oral feeds and wound settled. Adjuvant treatment is planned on receiving the histopathology report.

COMPLICATIONS

Excision of cancer of the buccal mucosa is surface surgery, and complications are usually related to the surgical procedure itself. These can be divided into immediate (occurring within 24 hours), intermediate (between 24 hours and hospitalization), and delayed (after discharge).

Immediate Complications

- Hemorrhage in the immediate postoperative period is the most common complication in this group. This usually occurs from a branch of the facial artery within the wound. The facial artery is suture ligated at the edge of the surgical defect to prevent hemorrhage.
- The marginal mandibular nerve is at risk of injury particularly when the cancer of the buccal mucosa is excised via a cheek flap. As the nerve runs 1 cm inferior to the inferior border of the mandible, the horizontal skin incision in the neck should be placed in the skin crease below this level, which is usually at least two finger breadths below the inferior border of the mandible. The nerve should be identified to safeguard against injury. The best and most consistent landmark is to identify the nerve in relation to the facial vessels (Fig. 3.14).
- Respiratory obstruction may be caused because of tongue fall particularly associated with extended resections of the mandible. An elective tracheostomy is indicated in such cases.

Intermediate Complications

- Secondary hemorrhage can occur due to intraoral infection. Prevention is the best to avoid this complication. Mouth washes and antibiotics should be encouraged in the postoperative period.
- Since excising the buccal mucosa is clean-contaminated surgery, the chances of wound infection is high. Adequate intraoperative antibiotic infusion and the use of appropriate antibiotics in the postoperative period decrease the probability of this complication. The chances are higher in systemic diseases like diabetes mellitus. Such patients should be monitored and kept under good glycemic control.
- Necrosis of the skin may occur as the result of faulty surgical technique or improperly placed incisions and using excessive cautery. Appropriate planning of incisions will prevent this complication.
- Hematoma or seroma results due to an inadequately functioning suction drain. This complication can be prevented by declotting the Hemovac drain or aspirating it. Rarely is evacuation of hematoma or seroma by way of reexploration required. Skin graft/flap failure: meticulous surgical technique, maintenance of intraoral hygiene, and frequent monitoring would prevent this complication. Quilting of the skin graft helps in achieving adequate immobilization, which also helps in graft take.

Delayed Complications

- Oral incompetence results when resection involves significant areas of the lip. Reconstruction needs to be appropriately planned in such cases. Every attempt should be made to preserve the commissures.
- Trismus results following contracture of the split-thickness skin graft when used for reconstruction. Large defects of the buccal mucosa therefore are best reconstructed with a radial artery forearm flap.
- Trismus may also result when resection is performed for posteriorly based lesions, which necessitates surgery in the region of the infratemporal fossa. Appropriate reconstruction, vigorous jaw stretching exercises, and physiotherapy can help minimize the extent of this complication.
- Fracture of the mandible is encountered in some patients following marginal mandibulectomy. This results from faulty surgical technique and leaving behind a thin strut of bone that is unable to withstand the forces of mastication. When performing marginal mandibulectomy, the osteotomies should be canoe shaped and the remnant height of the mandible should be at least a centimeter to prevent this complication.

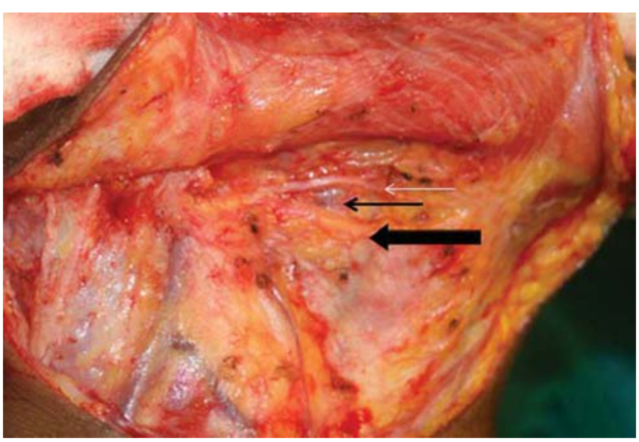

FIGURE 3.14 Relationship of marginal mandibular with fascial vessels. *White arrow* at marginal mandibular nerve, *thin black arrow* at the facial artery, and *thick black arrow* at the facial vein.

RESULTS

There are multiple factors that determine outcomes following excision of cancer of the buccal mucosa. These can broadly be divided into three groups—patients, histologic, and treatment related. While the patient and histologic parameters are predetermined, treatment (surgical) factors are under the control of the surgeon. The need for adequate excision with clear surgical margins is fundamental in achieving good locoregional control. In properly selected patients, peroral excision can lead to good results as borne out by our institutional study. Three-year actuarial overall survival rate and disease-free survival rates were 91% and 77%, respectively, after surgical therapy (peroral wide excision) for early squamous carcinoma of the buccal mucosa. Advanced cancer on the other hand has a guarded prognosis with the 2- and 5-year disease-free survival rates of 63.8% and 53.3%, respectively, for Stage III and IV cancers.

PEARLS

- Surgery is the mainstay of treatment for cancer of the buccal mucosa.
- Accurate planning and execution are important to give the patient the best chance of cure.
- CT scan is the imaging modality of choice and must be performed in all patients except in those with very early lesions. MRI is best suited for imaging recurrent lesions.
- Preoperative dental and plastic reconstruction consults are helpful.
- Peroral wide excision is most appropriate for superficial early anterior cancer that can be visualized in its entirety.
- Use cheek flap lip-split approach for deeper, more posterior cancers.
- Meticulous soft tissue three-dimensional clearance of the cancer.
- If the cancer abuts the mandible, or there is minimal erosion, marginal mandibulectomy is feasible, if not then segmental mandibulectomy should be performed.
- Appropriate reconstruction will limit postoperative morbidity and help with aesthetic outcome.

PITFALLS

- Inappropriately planned incisions results in skin necrosis.
- Paramandibular soft tissue involvement must be taken into consideration to avoid close soft tissue margins when planning marginal mandibulectomy.
- Inappropriate selection of the surgical approach results in close or positive margins.

INSTRUMENTS TO HAVE AVAILABLE

- Mouth gag
- Bard Parker scalpel with no. 10 or no. 15 blade
- Skin hooks
- Monopolar cautery
- Pick up forceps, Allis forceps, Babcock forceps
- Retractors: loop retractors, Langenbeck right-angle retractor, cheek retractor, tongue depressor
- Metzenbaum scissors
- Mayo scissors
- Gigli saw
- Powered oscillating saw
- Osteotome
- Humby knife
- Atraumatic vascular forceps
- Tooth extractor
- Drill with a burr

SUGGESTED READING

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4 OPERATIVE CONSIDERATIONS AND TECHNIQUES FOR PARTIAL GLOSSECTOMY

Kwang Hyun Kim

INTRODUCTION

Cancer of the oral cavity is the sixth most common cancer worldwide. Cancer of the tongue represents 2% of the annual cancer incidence in the United States with a male preponderance of 2:1. The prevalence of cancer of the tongue is much higher in certain Asian countries, especially where betel nut chewing is popular. However, the incidence of cancer of the tongue is also high in Eastern Europe and France, where smoking and alcohol intake are higher than in other countries. Despite the high incidence of cancer of the oral tongue, treatment outcome has hardly changed over the last few decades.

Histopathologically, squamous cell carcinoma is the most common form, which is further divided into three types: exophytic, ulcerative, and infiltrative. Cancer of the tongue is usually well differentiated. Small cancers of <1 cm may go undetected until the patient becomes symptomatic, or the cancer is detected by chance such as when a physical examination is done for other reasons. However, because the mobile tongue is readily visible and is relatively accessible, there is a good chance of detecting early lesions. Cancer of the tongue is usually found in the mobile tongue, most commonly on the lateral border. Approximately 75% of the cancers are located in the posterolateral aspect of the oral tongue, 20% in the anterolateral and ventral surface, and 3-5% on the dorsum. The lingual and hypoglossal nerves may be invaded directly by tumors, which may cause loss of sensation and deviation on tongue protrusion. Advanced cancer of the tongue is also associated with induration and ulceration of the tongue.

Surgery is still the mainstay of treatment for cancer of the oral tongue, especially in early cases. Partial glossectomy (PG) suffices in most cases of early cancers, especially those on the lateral aspect of the tongue. Minimal morbidity and good functional outcome are a big advantage of PG.

Relevant Anatomy

The root of the tongue rests on the floor of mouth (FOM) and is attached by muscles to the hyoid bone, mandible, styloid processes, and pharynx. The anterior and posterior limits of the mobile tongue are the lingual frenulum and the circumvallate papillae (sulcus terminalis). The oral tongue is a freely mobile portion of the tongue, which is also referred to as the mobile tongue. By definition, the muscular tissue posterior to the circumvallate papillae is the base of the tongue (BOT), which is a part of the oropharynx, although this boundary does not act as a barrier of tumor growth. The oral tongue is covered by stratified keratinizing squamous epithelium. Various taste buds cover the surface, including the filiform, fungiform, and circumvallate papillae (Fig. 4.1).

The surface topography of the mobile tongue reveals four anatomic regions: the tip, the lateral borders, the dorsum, and the undersurface or ventral surface (nonvillous surface). The tongue musculature is composed of three intrinsic muscles and three extrinsic muscles. The extrinsic muscles include the genioglossus, the hyoglossus, and the styloglossus muscles. The intrinsic muscles are composed of three groups of fibers

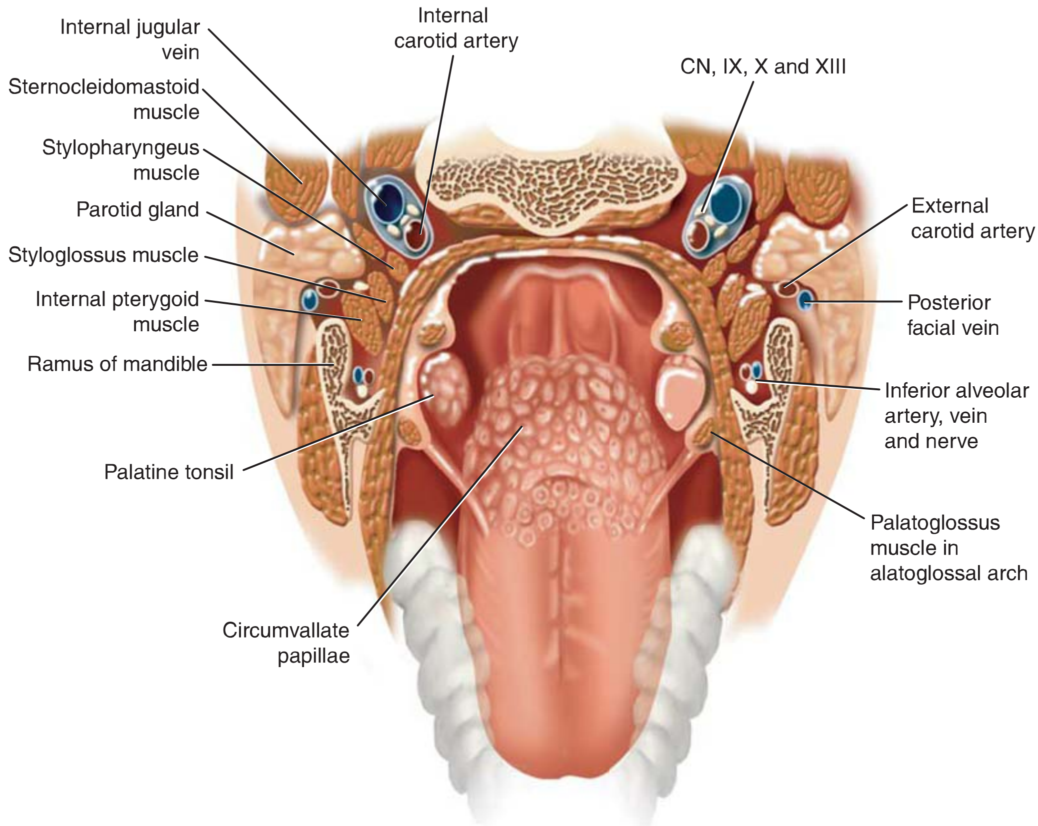


FIGURE 4.1 Tongue and its surrounding structures.

running in different directions, which are the superior/inferior longitudinal, vertical, and transverse muscles. The trilaminar group of intrinsic muscles is not attached to the bone. These six muscles together allow the mobile tongue to change shape and consistency, which enables various functions of the tongue such as speech and deglutition (Fig. 4.2).

The major blood supply of the tongue is the lingual artery, which is a direct branch of the external carotid artery. The lingual artery bifurcates at the level of the hyoid bone and courses anteriorly to reach deep into the hyoglossus muscle. The artery then branches off small tributaries in the ipsilateral tongue, which do not cross the midline. The artery travels further into the tongue toward the tip. Only then the arteries create an anastomosis with the branches from the contralateral side. The primary vein is the lingual vein, which flows into the internal jugular vein.

The main motor innervation of the tongue is supplied by the hypoglossal (CN XII) nerve. From posterior to anterior, the nerve courses between the hyoglossus muscle and the submandibular gland. Nerve fibers spread out to innervate the extrinsic muscles and are connected to the intrinsic muscles at its terminus. The lingual branch of the mandibular nerve (CN V3) delivers general sensation. Taste, from the taste buds, is conveyed by the chorda tympani nerve, which is joined by the lingual nerve and confluences into the facial nerve (CN VII) (Fig. 4.3).

The rich lymphatics in the tongue form the submucosal lymphatic plexus. Whereas the blood vessels cross the midline only at the tip, the lymphatics communicate freely from both sides which provide a route for cancer to spread in all directions. Lymphatics in the tip of the tongue drain into the submental lymph nodes. The dorsum and lateral tongue lymphatics flow into the ipsilateral submandibular nodes. Hence, these two lymph node groups form the first echelons of the lymphatic drainage of the mobile tongue. The lymphatic flow eventually drains into the deep jugular lymph nodes located between the digastric and the omohyoid muscles.

HISTORY

Detailed history taking is an essential initial step for the approach to the patient. Smoking habit and alcohol intake are essential part of the history. Functional status of the patient regarding the cancer should also be noted. Depending on the location of the cancer, the patient may have dysphagia, odynophagia, and dysarthria.

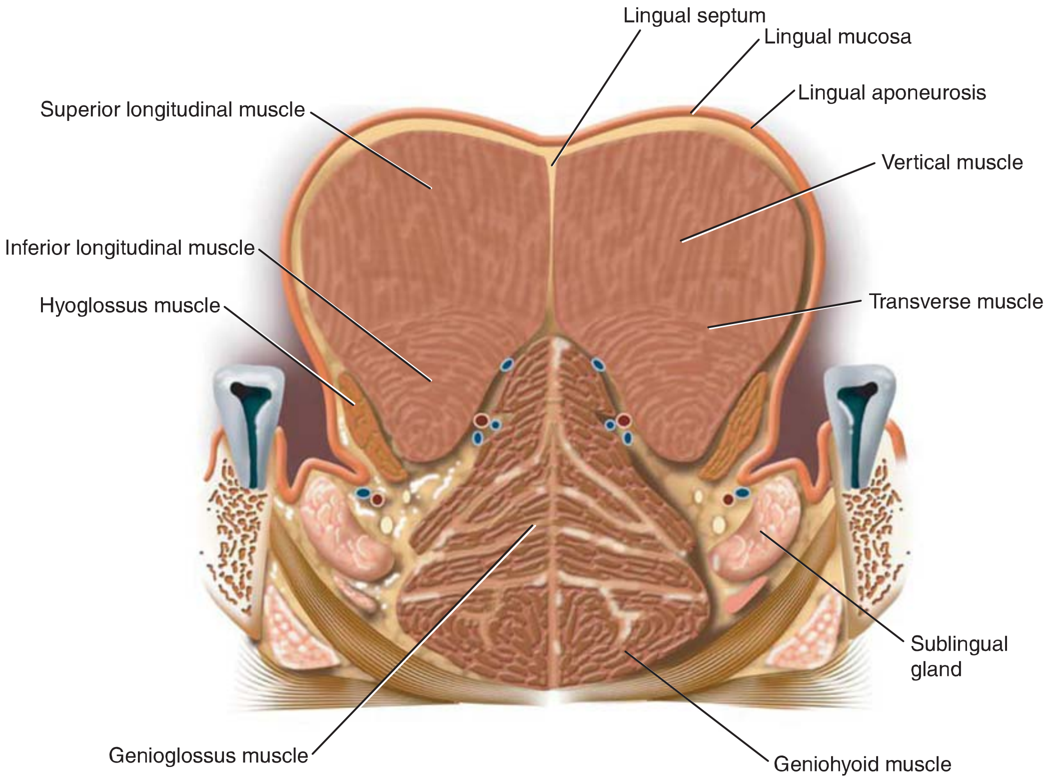


FIGURE 4.2
Coronal section through the tongue showing the intrinsic and extrinsic musculature.

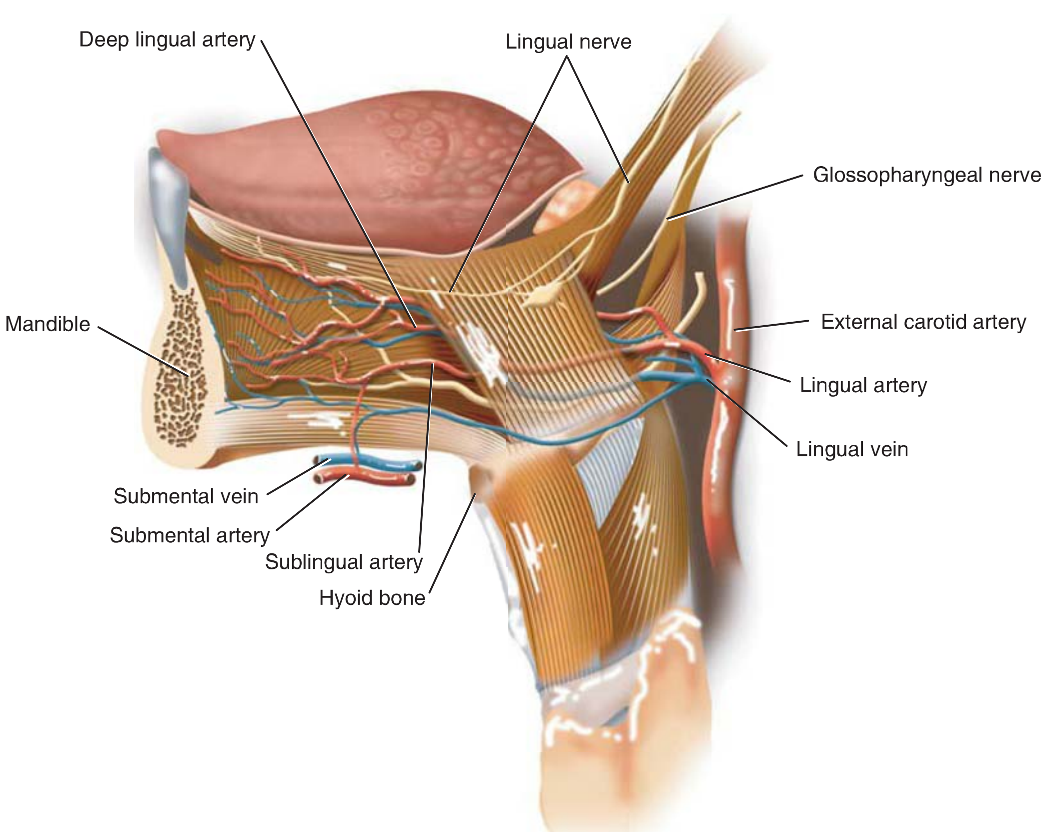


FIGURE 4.3
Vessel and nerve supply to the tongue.

Pain may be a sign of nerve involvement. History of a mass in the neck should be sought. The general condition of the patient, including weight loss and decreased appetite, should also be noted. Recent and remote dental treatment history should also be sought. Family history should not be omitted.

PHYSICAL EXAMINATION

Complete examination of the head and neck must be performed. This includes thorough inspection of the upper aerodigestive tract comprising the oral cavity, the pharynx, and the larynx using office endoscopy and laryngoscopy. The possibility of a second primary cancer should not be neglected even in early cancers. Panendoscopy (direct laryngoscopy and esophagoscopy) may be performed. However, it is not routinely performed as the benefit of a separate general anesthesia is not well established in early cancers of the mobile tongue. Examination of the neck for cervical lymphadenopathy is also mandatory. It is reported that 30% to 40% of patients with cancer of the oral tongue demonstrate evidence of cervical metastasis at initial presentation. Additional care should be taken when palpating the ipsilateral levels I–III as the sentinel nodes are usually located in this area.

It is advisable that examination of the teeth also be performed. In a significant number of patients, dental conditions require extraction of the teeth. This is especially important when postoperative radiotherapy is anticipated. If needed, thorough dental examination and/or tooth extraction may be performed by a dentist prior to surgery. However, for many patients, tooth extraction may be performed during the general anesthesia by the oral surgeons just prior to the main surgical procedure.

INDICATIONS

Early cancer of the mobile tongue is the primary indication for PG (T1, T2). Carcinoma in situ and leukoplakia with heterogeneous features are less common indications. Early T3 lesions may be an indication for PG, when the cancer is situated anteriorly and laterally. Patients with lesions in the lateral tongue are good candidates for PG.

CONTRAINDICATIONS

PG may not be suitable for advanced T3, T4 primary cancer of the tongue. Although it may be applicable, the morbidity and resulting functional deficit may not be acceptable. There also is a concern for oncologic safety regarding obtaining adequate surgical margins and excessive manipulation of a large volume cancer. Cancer invading into adjacent structures is also a contraindication. Location of the cancer where obtaining adequate margins is expected to be difficult is also a contraindication for PG. Cancers located in the posterior aspect of the mobile tongue adjacent to the BOT are especially difficult to completely excise by PG, which makes it a contraindication for this procedure.

Cancer crossing the midline of the tongue also precludes a PG. Because PG requires preservation of one lingual artery and one hypoglossal nerve, tumor infiltration beyond the midline with proximity to the contralateral neurovascular bundle is a contraindication for PG.

Other relative contraindications to this procedure include poor general medical condition, making general anesthesia difficult or risky, and patient refusing to undergo the procedure (Table 4.1).

TABLE 4.1 Indications and Contraindications for Partial Glossectomy

	Indications	Contraindications
Size	T1, T2, early T3 primaries	Advanced T3, T4 primaries Cancer crossing the midline
Location	Lateral mobile tongue	Posterior Adjacent to the BOT, FOM
General	Good general condition	Poor general medical condition Patient refusal

PREOPERATIVE EVALUATION

Gross inspection of the cancer, especially the size and location, is essential when planning the management strategy for a cancer of the mobile tongue. Cancer located in the anterolateral region of the tongue is more amenable to PG, whereas cancer located posteriorly needs alternative approach methods even when the cancer is small.

Bimanual palpation is also an important part of the examination that may reveal critical information as to the extent of the tumor. It may be difficult to obtain adequate deep resection margins if the tumor has an infiltrative margin. On the other hand, an exophytic tumor does not necessarily represent a shallow tumor. It is equally important in that palpation also gives an idea of the remaining normal tongue. Palpation should also be used to evaluate whether the cancer has crossed the midline and whether it is fixed to adjacent structures. In some patients, examination of the tongue may be so painful that valuable information cannot be obtained. These patients must be examined under general anesthesia. Incisional biopsy must be performed for pathologic diagnosis to aid management plans. Deep biopsy and adequate volume are mandatory for proper pathologic diagnosis. If the cancer contains necrotic portions or an ulcer crater, viable tumor tissue should be sought, preferably along the tumor growth margin. For leukoplakia, wide biopsy should be performed in areas where concomitant carcinoma is most likely to be found, avoiding sloughed necrotic areas.

Cervical lymphadenopathy, if present, must also be evaluated pathologically. Abnormal cervical lymphadenopathy may be detected by palpation on physical examination, or by radiologic evaluation or ultrasound. Fine needle aspiration (FNA) is a safe, simple, and the most commonly utilized method for initial pathologic evaluation of a node. If the node is not palpable, ultrasonography may be used to assist the procedure. If FNA is inconclusive, core needle biopsy may be performed.

Computed tomography (CT) scan is an elemental preoperative imaging study that should be performed whenever possible. Size, depth, extent, and relation to adjacent structures should be evaluated. Cervical lymphadenopathy should also be identified, with special attention to levels I–III. One should bear in mind that the probability of metastasis to the neck increases with tumor depth. Although cancer of the mobile tongue rarely invades the mandible, the cortex of the mandible should be scanned carefully for any evidence of destruction of cortical bone.

Magnetic resonance imaging (MRI) is also very helpful in evaluating the primary cancer, because it has excellent soft tissue resolution. An advantage of MRI is high tissue contrast between the cancer and normal muscle on T2-weighed images. Also, contrast between radiation fibrosis and recurrent cancer is improved on T2-weighed images. The MRI is especially helpful when denture artifact precludes evaluation of the primary cancer by CT scan. MRI also provides coronal and sagittal views, which aid greatly in evaluating the depth of the cancer.

Evaluation for distant metastasis, including positron emission tomography (PET), can be performed as well. However, distant metastasis is seldom found in early cancer of the tongue, so systemic metastasis evaluation may be omitted in early mobile tongue cancers without any risk (Fig. 4.4).

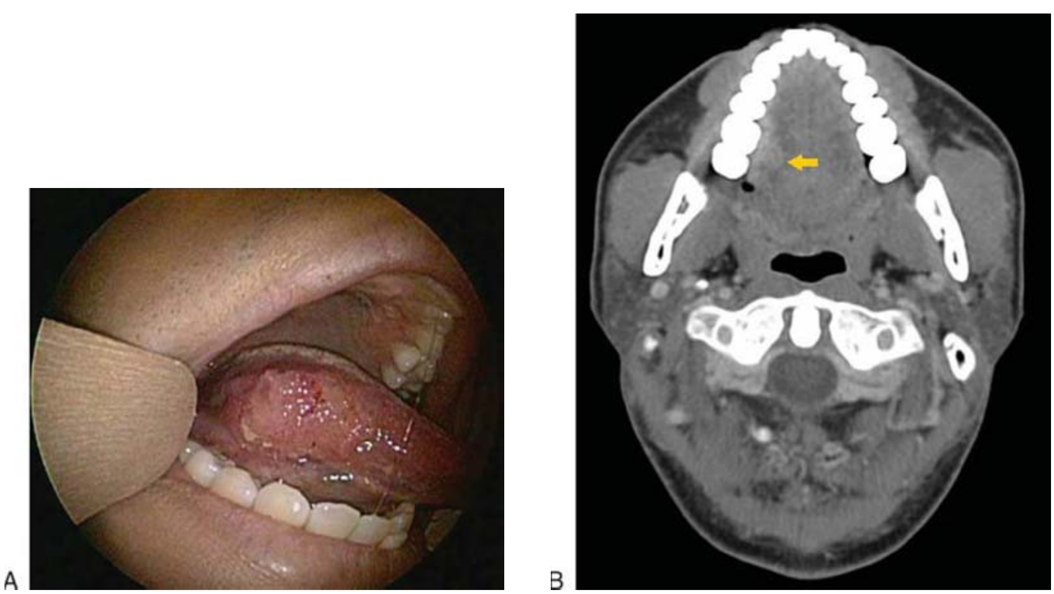


FIGURE 4.4
A case of carcinoma of the lateral mobile tongue with preoperative evaluation.
A: Gross morphology.
B: Axial CT scan with contrast enhancement (*arrow*).

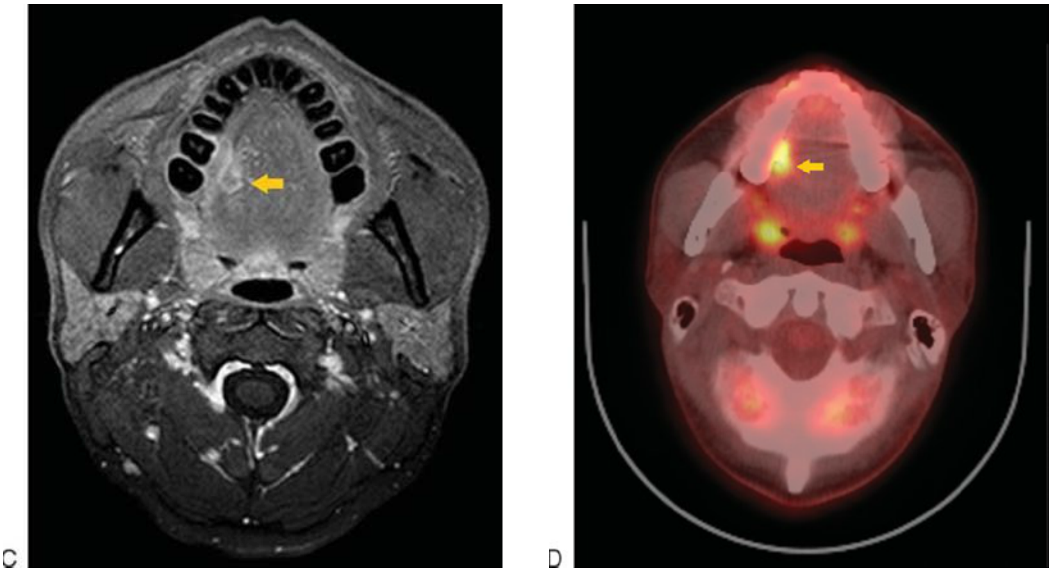


FIGURE 4.4 *(Continued)* **C:** T1-weighed MRI scan with gadolinium enhancement (*arrow*). **D:** Fusion PET-CT scan with high SUV at the site of the lesion (*arrow*).

SURGICAL TECHNIQUE

Preoperative Details

PG is performed under general anesthesia. Orotracheal intubation is preferred, but nasotracheal intubation is also an option if concern regarding exposure is anticipated. Orotracheal tube should be fixed to the contralateral angle of the mouth. The patient is placed in Rose position with the neck hyperextended. Routine preoperative preparation is applied. Surgical lights can be used, but a head lamp gives a much better view of the oral cavity. Light sources such as halogen or xenon provide good illumination.

When neck dissection is planned, this should also be considered when draping is done. Neck dissection, typically of levels I–III supraomohyoid neck dissection (SOND), may be required. For early primary tumors with a clinically N0 neck, 20% to 30% of elective neck dissection specimens are found to be pathologically positive.

OPERATIVE TECHNIQUES

When neck dissection is planned, it is the surgeon's preference as to the order in which the operations should be performed. Customarily, neck dissection is performed prior to PG because the neck dissection field is a sterile operative field, whereas the oral cavity is clean contaminated. In case a free tissue transfer is planned, some surgeons may feel more comfortable in finding the recipient vessels prior to moving on to the primary tumor resection. However, I have found that free tissue transfer is rarely necessary in case of PG. In some cases, neck dissection may be determined intraoperatively only after checking the depth of invasion of the primary cancer. In this instance, resection of the primary may be performed first. The latter case may be used to permit frozen section margin analysis during the neck dissection if planned (Table 4.2).

TABLE 4.2 Preoperative Checklist

Preoperative Checklist
Gross inspection and thorough palpation
Pathologic confirmation of the primary cancer (incisional biopsy) cervical lymph node (FNAB)
Imaging studies—neck CT with contrast enhancement
Good light source
Frozen section control—have a pathologist ready

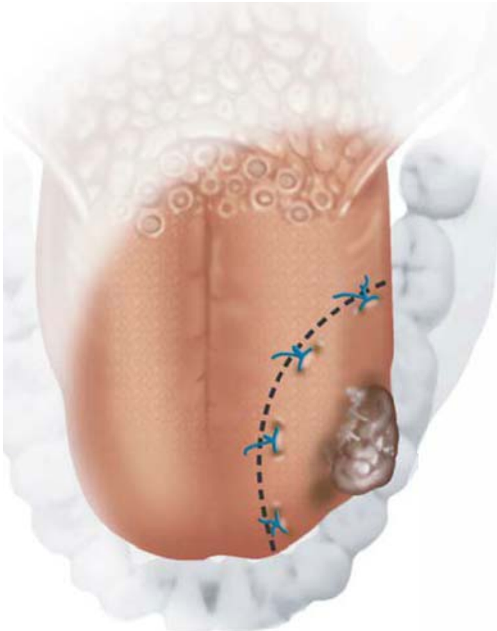


FIGURE 4.5 Planning of PG for cancer of the lateral mobile tongue.

A Denhardt mouth gag is applied for exposure, with caution not to damage the teeth. As previously mentioned, dental extractions may be performed at this time, as needed (Video 4.1). Thorough palpation of the tumor is performed once again for extent of induration. A stay suture using 2-0 silk is applied on the tip of the tongue, which provides excellent operative view. The outline of the resection margin is marked on the surface of the tongue. Placing a generous margin of 1.5 cm should be sufficient. I use a Bovie scalpel to make a dotted line around the cancer. Stay sutures may also be placed on the line of resection. Typically four to six stay sutures are placed around the tumor. This helps to continuously maintain good exposure and also to keep track of the projected surgical margin. Iodine staining is used by some authors to decide on an excision margin for dysplasias of the tongue. However, good palpation and visualization suffice in most cases (Fig. 4.5).

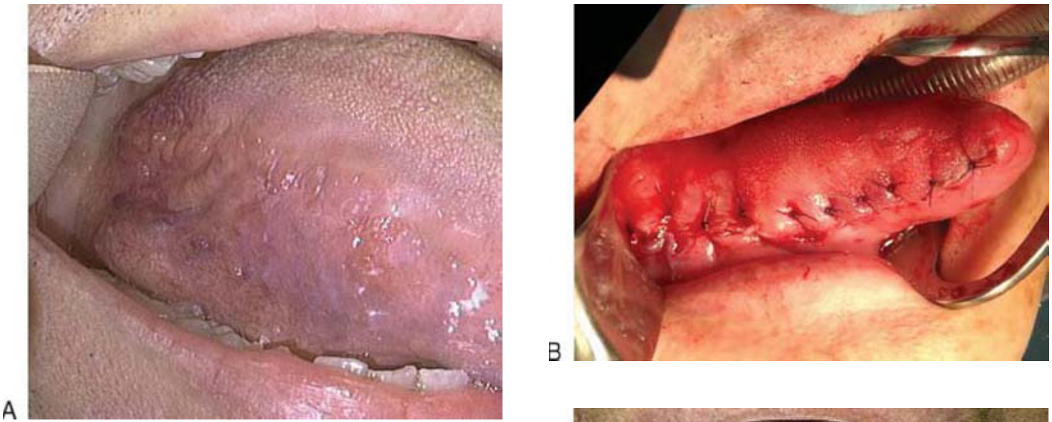
Various instruments can be employed in PG. Cold knife has been used in the far past, but too much bleeding has limited its use in the current era. The most commonly used is electrical diathermy, or Bovie scalpel. Resection can also be performed using carbon dioxide laser. Recently, an ultrasonic device called the Harmonic scalpel has been introduced for use in PG.

Traditionally, electrocautery, especially the Bovie scalpel, has been an excellent tool for excision, which facilitates quick dissection through the bulk of tongue muscle. Hemostasis can be achieved using the Bovie scalpel, or a bipolar cautery. A margin of 1.5 cm is maintained around the tumor in all dimensions throughout the excision. Both visual assessment and palpation of the tongue should guide the excision. The cancer should be continuously palpated with the other hand in order to maintain this cuff of tissue around the tumor. Care is taken not to cross the midline and violate the contralateral neurovascular bundle containing the lingual artery and the hypoglossal nerve.

In the recent years, I have found that the Harmonic scalpel is a good alternative to the Bovie electrocautery with regard to operative time and hemostasis. Because the tongue is a very vascular tissue, much time is dedicated to hemostasis when a Bovie scalpel is used. Each bite using the Harmonic scalpel may seem tedious, but because time allocated to hemostasis on the whole is considerably decreased, overall time seems to be equal or

TABLE 4.3 Operative Instrumentation

Instrumentation
Denhardt mouth gag, cheek retractor
Bovie scalpel
Electrical diathermy (bipolar cautery)
Harmonic scalpel



A B

C

FIGURE 4.6 A: Shallow ulceration in the lateral mobile tongue. **B:** Primary closure after PG. **C:** Four months postoperative after primary closure.

faster when Harmonic scalpel is used. Harmonic scalpel can coagulate vessels up to 6 mm in diameter, which includes the lingual artery and vein. Postoperatively, better wound healing is observed as the Harmonic scalpel does not produce as much heat and electrical burn to the tissue (Table 4.3).

Following excision of the cancer, the specimen should be adequately labeled so that pathologic examination can be done in proper orientation. Resection margins should be evaluated again ex vivo. Thickness of the tumor may also be assessed, as it is an important prognostic factor in tongue cancer.

Frozen sections of the margins are mandatory. Frozen section biopsy should be taken from the anterior and posterior margins, medial and lateral (or dorsal and ventral) margins, and the deep margin. It is best done using a cold knife to minimize cautery artifact. If there is any doubt that the tumor margin may be too narrow, the resected specimen can be cut to evaluate the depth of resection margin.

Obtaining a suitable deep resection margin may be problematic. The surgeon should continuously palpate the mass during the resection. There is a tendency for the lateral margin to be too much and the deep margin to be rather shallow. Intraoral sonography-assisted resection may be used for securing an adequate deep resection, although not yet widely accepted. Scrupulous palpation in experienced hands is usually sufficient for obtaining adequate margins.

No drain is placed in the primary tumor site. Primary closure is sufficient at most times after PG. Healing by secondary intention can be an acceptable option. Skin grafting with split-thickness skin graft or a fasciocutaneous free flap such as the radial forearm free flap or anterolateral thigh flap may be used but is seldom necessary. Many studies have reported that speech intelligibility is better in patients not receiving grafts. Morphologic alterations do remain after resection, but functional results after primary closure is excellent. Some authors advocate transverse wedge resection and horizontal closure to avoid a long pointing tip (Fig. 4.6).

POSTOPERATIVE MANAGEMENT

After recovery from anesthesia, the patient is transferred to the ward. Intensive care unit care is usually not indicated. Tracheostomy and/or nasogastric tube feeding is usually not required. Oral feeding is resumed on the day after the operation. Discharge is planned as soon as the patient can tolerate a sufficient diet. Although no specific rehabilitation protocol is necessary in most cases, a speech therapist may be helpful in training the patient for swallowing and speech.

Need for adjuvant management strategies such as radiotherapy should be considered according to the outcome of the surgical pathology.

COMPLICATIONS

General complications following PG may include bleeding and infection. If the resected surface is closed primarily, dehiscence may occur in areas of excess tension. Close observation and waiting to heal with secondary intention may suffice in such instances. Disfigurement of the tongue may persist in varying degrees, although at most times it is functionally well tolerated. If a free flap is used, complications regarding the flap, including flap loss, should be considered.

As the surgery is limited to less than half of the tongue, functional debilitations such as speech and swallowing impairment are not seen frequently following PG. Most patients adapt to the postoperative state eventually, but some patients may need rehabilitative measures. Numbness of the tongue or neuralgic pain may be a problem in a small number of patients.

Lastly, if it be regarded as a complication, local recurrence might be the most problematic. I cannot overstate the importance of a generous resection margin control at the initial attempt.

RESULTS

Survival after PG is excellent. The 5-year survival rate for early cancers of the oral tongue Stages I and II is reported to be 75%. Morphologic outcomes are acceptable in most cases. Functional outcome, including swallowing and speech functions, is excellent. However, in some cases recurrence appears early on in the primary site or the neck, which makes the prognosis quite unfavorable. Therefore, thorough neck dissection of levels I–III is mandatory when the tumor is infiltrating the muscle layer of the tongue. The need for adjuvant radiation or chemoradiation is based on pathology reports and criteria, including extracapsular spread in lymph nodes, multiple lymph nodes, and perineural invasion.

PEARLS

- With good exposure and good illumination, this procedure is simple, easy, and not time consuming.
- Tumor can be palpated well to get appropriate margin. Bleeding is minimal if you use the Harmonic scalpel.
- Margin control is easy by taking frozen sections from all four sides and the deepest portion of the excised specimen.
- Function is usually not disturbed, and the tongue volume is restored by time.
- Radiation therapy would not be necessary if the neck is negative by SOND or sentinel node biopsy.

PITFALLS

- This technique is not indicated for deeply infiltrating cancers crossing the midline.
- Primary closure is sometimes not easy, and a skin graft or a free flap may be required.
- Wound dehiscence can happen but usually heals well.
- The shape of the tongue could become slightly deviated or angulated to the resected side.
- Reduction in the volume of the tongue may not be enough for chewing and swallowing. But the problem happens only rarely and is compensated well afterward.

INSTRUMENTS TO HAVE AVAILABLE

- Denhardt mouth gag, cheek retractor
- Bovie scalpel
- Electric diathermy (bipolar cautery)
- Harmonic scalpel

ACKNOWLEDGMENT

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5 TOTAL GLOSSECTOMY

Luiz Paulo Kowalski

INTRODUCTION

Malignant tumors of the head and neck represent about 6% of all human cancers, and squamous cell carcinoma of the oral cavity is the most frequent of these tumors. The majority occur in the tongue or floor of the mouth and are asymptomatic at onset, and, in spite of the easy access for clinical examination, the diagnosis is usually established at advanced clinical stages. By then, several major problems such as severe pain, dysphagia, bleeding, weight loss, and cervical lymph node metastasis are present.

The gold standard of care for patients with advanced cancer of the tongue and floor of the mouth has been surgery as the first therapeutic option, with radiation and/or chemoradiation used as adjuvant treatment. Nonsurgical modalities, such as radiotherapy alone or chemoradiation, are not considered the treatment of choice due to the low radiosensitivity, high cost, severe treatment-related symptoms, early and late morbidity, and expected lower survival rates when compared to primary surgical treatment. Patients initially not treated surgically because of comorbidities or refusal can be candidates for major salvage surgery for persistent or recurrent locoregional disease.

Current initial or salvage surgical treatment planning for patients with advanced stage cancer is based mainly on the site and size, adjacent areas involved, neck and distant metastasis, histology, comorbidities, and the patient's performance status.

The surgical procedure is composed of three parts: the treatment of the cervical lymph nodes, wide resection of the primary cancer, and immediate reconstruction. Total glossectomy is a technically simple operation for head and neck surgeons, but it should be done only in tertiary hospitals with an experienced team who are prepared to deal with a difficult postoperative course. It is mandatory to have a multidisciplinary rehabilitation team with experience in the management of patients with significant long-term aesthetic and functional sequelae. Total glossectomy has been considered a major challenge because of the functional consequences that cause major effects on the patient's quality of life. Recent advances in reconstructive techniques, including myocutaneous flaps, free flaps, prosthesis, and implants, along with the development of speech and swallowing therapy drastically changed this picture, and now it is considered an acceptable therapeutic option for a highly selected group of patients.

In the study published by Weber et al. with 27 patients who underwent total glossectomy with laryngeal preservation, a laryngeal suspension was done in 12 patients and 18 had a palatal augmentation prosthesis inserted. Only 2 out of the 27 patients required salvage laryngectomy due to persistent aspiration, and the rates of speech and swallowing rehabilitation were 92% and 67%, respectively. Similar results were described by Tiwari et al, Bova et al, and Yanai et al, in series of 21, 20, and 20 patients, respectively. According to Sessions et al, total glossectomy should be regarded as a major achievement in the treatment of advanced cancer of the tongue. The indication for this operation should be based either on the possibility of returning the patient to productive life or on the need for palliation of an intolerable clinical condition such as pain, hemorrhage, dyspnea, or dysphagia.

One of the largest series of total glossectomies was published by Gehanno et al. in 1992, which included 80 patients submitted to total glossectomy either primary (36 cases) or salvage (44 cases). The same authors recently published a series of 109 patents (Barry et al.). They have shown that the inclusion of a mandibulectomy and the need for laryngectomy had a negative impact on survival and functional outcomes. Their main recommendation was that this surgical procedure should be done only for patients who are well motivated and have good support systems. Yu and Robb in 2005 reviewed the Anderson experience of 94 patients submitted to total glossectomy describing some reconstructive innovations such as the use of a lateral thigh flap (21 patients) with reinnervation (11 patients). Unfortunately, these new reconstructive procedures did not add significant advantage in functional outcomes when the patients were also submitted to adjuvant radiation therapy after the total glossectomy.

Magrin et al. reviewed a series of 106 patients who underwent total glossectomy; the majority of patients had acceptable functional results except for a few patients who had persistent aspiration. The multivariate survival analysis identified T stage (T4), number of metastatic lymph nodes (>3), and male gender as predictors of the risk of death. It was also noted in univariate analysis that none of the patients with tumor extension to three or more adjacent sites survived for 5 years. This is a clear limit for the indication of an extensive and mutilating surgical procedure.

HISTORY

The classical description of a patient with cancer of the oral cavity is that of a male, over 50 years old, who is a tobacco smoker and alcohol drinker. This is not only inaccurate but it can obscure clinical judgment and lead to a considerable delay in diagnosis because patients, dentists, and physicians frequently do not consider cancer of the oral cavity among the differential diagnosis of those that do not fit this profile. In fact, cancer of the oral cavity can be seen in males and females of any age and independent of tobacco and alcohol consumption. In recent years, the incidence of oral cancer has been growing among females, young persons, and nonsmokers. Furthermore, although cancer of the tongue and floor of the mouth are usually squamous cell carcinoma, several other malignant tumors with a different natural history can occur in this anatomic site. These are cancers of minor salivary gland origin, sarcomas, lymphomas, or metastatic cancer from distant sites.

Most cancers of the tongue and floor of the mouth arise de novo in areas of macroscopically normal mucosa and are not symptomatic at onset. The most common complaints are a persistent and painless ulcer that progressively causes some discomfort or local irritation. After several weeks or months, the locoregional progression can cause pain, dysphagia, bleeding, trismus, sialorrhea, palpable metastatic lymph nodes in the neck, weight loss, and other local or systemic complications.

PHYSICAL EXAMINATION

Initial clinical examination must be done to assess the primary tumor site and extension, presence of cervical lymph node metastasis, and to rule out the presence of a second primary cancer in the mucosa of the upper or lower aerodigestive tract. Squamous cell carcinoma is usually ulcerated (exophytic or invasive), whereas other malignant tumors present as submucosal nodules or infiltrating and nonulcerated lesions. The visual examination must be associated with palpation because the area of infiltration is usually much larger than the ulcer or nodule on the surface. The adequate examination includes the appearance of the tumor, location, areas involved, anatomic boundaries, proximity or involvement of the mandible, mobility, diameter, and estimated thickness. The presence of trismus and the patient's dental status are also important findings. Examination of the oropharynx and a laryngoscopy complete the examination and are important in the detection of second primary cancers. Examination of the head and neck is concluded with a thorough palpation of the neck aiming to detect lymph node metastasis. The number, size, consistency, location (level), and mobility of the nodes must also be recorded.

INDICATIONS

The indications for a total glossectomy must be individualized considering tumor factors, patient-related factors, and the possibility of reconstruction and rehabilitation. The primary or recurrent advanced cancer of the tongue crossing the midline and involving the base of the tongue and oral tongue that is suitable for total glossectomy with laryngeal preservation is the one that can be resected with clear margins including or not the floor of the mouth, tonsils, and mandible.

CONTRAINDICATIONS

More advanced cancers, involving the maxilla, nasopharynx, posterior oropharyngeal wall, and hypopharynx are usually not considered for this operation because of the very poor functional and survival outcomes that can be expected. However, with some technical variations, patients with advanced cancer confined to midline

structures, or with minor involvement of the lateral wall of the oropharynx that involves the vallecula and larynx, can be submitted to a total glossolaryngectomy. There is no indication for the operation in the patients with fixed N3 neck metastases nor with distant metastasis.

The indication of total glossectomy for surgical salvage has several additional limitations and usually can be defined only after a meticulous examination under general anesthesia because most of the times it is difficult to define the tumor limits in an area with different degrees of fibrosis resulting from chemoradiotherapy, and there is a high risk of major postoperative complications. However, salvage surgery must be always considered as an option in patients with locoregional recurrence because it is the only potentially curative option considering that chemotherapy is not curative, and in most cases it is not possible to use an additional course of radiotherapy particularly when the initial radiation was not curative. The most favorable group of eligible patients for salvage surgery is that with recurrent cancer at initial clinical stages and diagnosed after 1 year of initial treatment.

Several improvements in anesthetic and surgical ablative and reconstructive techniques allowed the implementation of more radical oncologic procedures for the treatment of advanced cancer of the head and neck. However, the indications for these procedures can be limited by the potential hazard of severe complications and sequelae. Unfortunately, there is no specific scoring system to predict rates and degrees of morbidity in patients with advanced cancer of the oral cavity.

Total glossectomy is a surgical procedure suited just to patients with a good performance status and without severe comorbidities. It also depends on the patient's ability to handle saliva and secretions because the degree of postoperative aspiration can be intense in some patients. Other potentially significant factors are patient motivation, social factors, and family support. These factors are of paramount importance for patient's acceptance of a surgical procedure that can cause significant sequelae requiring long period of hospitalization and compliance with an extensive rehabilitation program. Not surprisingly, we recently reported the long-term acceptance of major surgeries, including total glossectomy, in a series of 261 treated patients with advanced cancer of the head and neck. More than 60% reported a good-to-excellent global quality of life, and 95% reported that they would not like to change their present outcome for another treatment option with a lower chance of cure but with possible improvement of quality of life.

PREOPERATIVE PLANNING

An incisional biopsy of the primary cancer is usually done at the time of the first examination. If a biopsy was previously done in another institution, the slides and paraffin blocks are requested in order to be reviewed by an experienced oral pathologist. It is also important to have histologic confirmation for recurrent cancers. An extensive and mutilating surgical procedure should not be done without histologic diagnostic confirmation. Biopsy of the cervical lymph nodes is not necessary and, in fact, most of the time is contraindicated.

A comprehensive preoperative clinical evaluation is always mandatory for all candidates for total glossectomy because the operation may produce remarkable functional deficits, and rehabilitation requires a motivated patient and the cooperation of an experienced multidisciplinary team (surgeons, dentists, and speech therapist). To be considered eligible for a total glossectomy with laryngeal preservation, the patient must have a good performance status, without significant comorbidities, and have an adequate pulmonary reserve to clear secretions. This is similar to the selection process for partial laryngeal surgery. All patients require a temporary tracheostomy after the operation due to aspiration.

Medical history, including the presence of comorbidities (ACE27), physical examination, as well as evaluation of the nutritional and performance status (Karnofsky or ECOG criteria) are important for treatment planning. Nutritional support can be indicated prior to surgical treatment using a nasogastric feeding tube or a percutaneous endoscopic gastrostomy (PEG). Consultation with a dentist is necessary for evaluation, possible dental extractions, and preparation of a prosthesis and dental implants. Most patients will require reconstruction with a myocutaneous or a free flap, and preoperative evaluation is important for planning this aspect of the surgical treatment.

Preoperative anesthesiology evaluation and grading of anesthesia risk by American Society of Anesthesiologists criteria and planning for airway management are also mandatory. Evaluation of airway changes, range of motion of the neck, and distance from the mandible to the thyroid notch is important to predict difficult tracheal intubation. Psychological or psychiatric evaluations should be recommended for selected patients and families. Consultation with physical therapy and speech and swallowing specialists must be done preoperatively, aiming to introduce these supportive care specialists who will be of paramount importance postoperatively.

Imaging studies (computed tomography [CT], magnetic resonance image [MRI]) are mandatory to ascertain the extent of advanced cancer of the tongue and floor of the mouth. Axial and coronal views, with bone and soft tissue windows (CT), and axial, coronal and sagittal views (MRI) are obtained to demonstrate the areas of tumor involvement. A CT scan of the mandible (Dentascan) may be necessary for confirmation of minor involvement of the mandible. More than 50% of the patients with advanced squamous cell cancer of the tongue and floor of the mouth have cervical lymph node metastases at presentation. None of the currently available

imaging studies are accurate in detecting small (<5 mm) and clinically negative neck metastasis. For larger metastatic lymph nodes (cN2-N3), CT or MRI can demonstrate extracapsular spread, involvement of adjacent structures, and contralateral metastases.

The risk of distant metastasis in patients with advanced locoregional disease can be as high as 20% to 30%. A CT scan of the chest and superior abdomen is recommended as part of the initial evaluation and is cost-effective in this clinical situation. A positron emission tomography (PET-CT) does not have good image resolution for evaluation of the primary cancer, but it can be used to stage distant metastasis in patients with advanced primary oral cancer, and it is also considered mandatory in preoperative evaluation for salvage surgery of recurrent cases.

After histologic confirmation and conclusion of all noninvasive clinical and imaging evaluations, the clinical staging of the tumor is done, using the TNM American Joint Committee on Cancer /Union for International Cancer Control criteria. This information is useful for treatment planning, prognosis evaluation, and report of long-term treatment results.

SURGICAL TECHNIQUE

The planning of a total glossectomy must be meticulous and always includes

1. Anesthesia and airway management
2. Reexamination under general anesthesia
3. Patient position and mucosal and skin preparation
4. Planning of incisions
5. Bilateral neck dissection
6. Tracheostomy
7. Access to the oral cavity
8. Management of the mandible
9. En bloc tumor resection of the cancer with clear margins
10. Larynx suspension
11. Reconstruction options

The operating table must be properly padded so that pressure points that may lead to scar formation because of the long duration of the procedure are eliminated.

Intravenous antibiotic therapy begins before surgery. Monitoring systems are applied, and general anesthesia is induced. The intubation may be a major challenge for the anesthesiologist due to difficult airway anatomic changes caused by tumor size or infiltration. The patient is usually intubated with an endotracheal tube placed through the nasal cavity, oral cavity, or tracheostomy. Whenever difficult intubation is anticipated, bronchoscopy-guided intubation with the patient awake or a tracheostomy is performed. The surgeon and the anesthesiologist must agree on the most appropriate position of monitors and the tracheal tube.

Patients with advanced cancer of the oral cavity frequently have severe pain, and clinical examination can fail to ensure the possibility of a radical resection with clear margins. Reexamination under general anesthesia is mandatory to ascertain the extent of the tumor. Examination through the open mouth must be followed by direct laryngoscopy, frequently combined with telescope magnification for a comprehensive evaluation of the most difficult areas. Finally, a thorough palpation of the oral tongue, floor of the mouth, tonsil area, and base of the tongue completes the examination.

The patient is positioned on the operating table in the supine position with the neck extended. A nasogastric tube is inserted, and sterile preparation of the nasal cavity, oral cavity, and pharynx is done. The facial, neck, and thorax skin is shaved, scrubbed, and then prepared with povidone–iodine or chlorhexidine solution.

The approach to the primary cancer requires excellent exposure of the cancer and resection with clear tridimensional margins. Advanced cancer of the tongue and floor of the mouth has high rates of bilateral cervical lymph node metastases. Neck dissection depends on the clinical stage of the neck: (a) cN0 or cN1 at upper levels is the indication for bilateral selective neck dissections (levels I–IV); (b) other resectable cN1-N3 is the indication for modified or classical neck dissection on the highest stage side of the neck, and modified radical (with preservation of the internal jugular vein) or selective dissection of levels I–IV on the contralateral side. An apron-like incision from slightly inferior to the mastoid tips to the hyoid bone is done in cases of bilateral selective dissections. A curved incision from mastoid tip to mastoid tip overlying the cricoid and from this incision at the level of the posterior border of the sternomastoid muscle, an S-shape incision starts and ends at the middle of the clavicle (uni- or bilaterally) is performed in cases of radical neck dissection (Fig. 5.1).

The pharynx is packed with 3 or 4 fluffed-out gauzes. These gauzes must be tied with a 2-0 suture. In cancer involving the mandible, the superior flap of the bilateral neck dissection is raised farther subperiosteally, and both submental nerves are sectioned. The dissection stops at the level of the alveolar process in areas without bone invasion. Whenever there is cancer involving the mandible, the flap elevation must consider the necessary soft tissue margins, and in this particular site it is elevated above the periosteum. In some occasions,

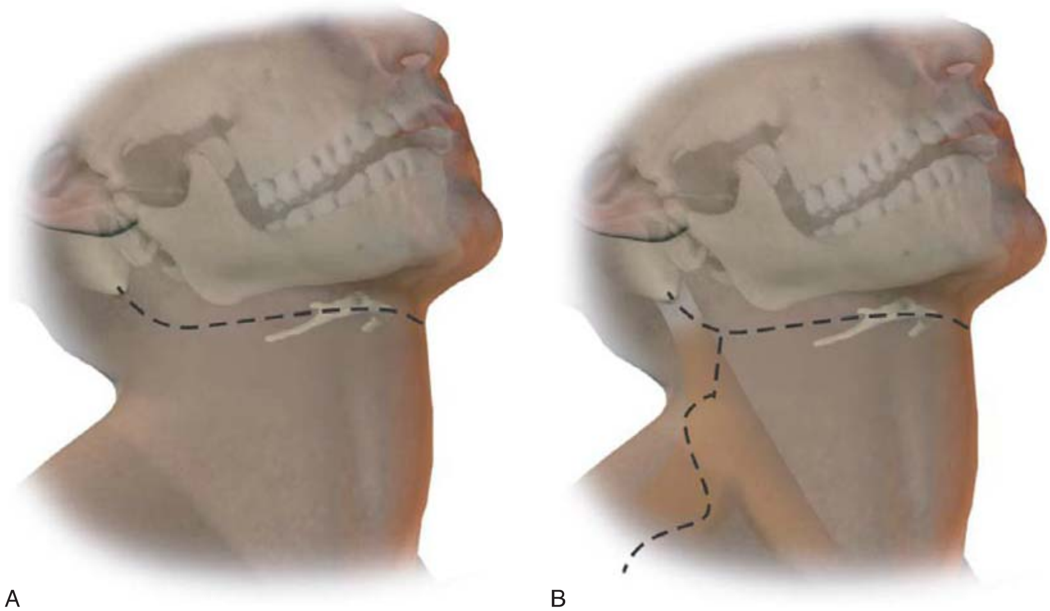


FIGURE 5.1
Incisions for neck dissection. **A:** Incision from slightly inferior to the mastoid tips overlying the hyoid bone. **B:** Curved incision from mastoid to mastoid tips overlying the cricoid, and from this incision at the level of the posterior border of the sternomastoid muscle, an S-shape incision starts and ends at the middle of the clavicle (uni- or bilaterally).

it is necessary to consider a lip-split approach. From the oral cavity, the buccal and lower lip mucosa is incised under direct vision usually at immediately outside the gingival margin, thus allowing the retraction of the flap superiorly. A marginal, sagittal, segmental, or more extensive resection of the mandible is done with clear margins according to the size of macroscopic and radiologic evidence of tumor invasion (Fig. 5.2). For tumors close to the mandible or with minor mandibular involvement, a marginal or sagittal mandibulectomy can be performed (pull-through procedure). The contraindications for marginal and sagittal mandibulectomy are invasion of the mandibular canal or massive soft tissue surrounding the bone. In the edentulous and previously radiated mandibles, a marginal or sagittal mandibulectomy is also contraindicated due to the high risk of fracture and recurrence. If the bone is involved up to the mandibular canal, a segmental, hemi-, subtotal, or total mandibulectomy is necessary.

For the cases without involvement of the mandible, it is not necessary to raise the superior flap. In such cases, a pull-through procedure is done. The periosteum of the mandible is incised along the inferior border of the mandible, and the internal aspect is removed up to the level of the myelohyoid muscle (Fig. 5.3). The insertion of the digastric, mylohyoid, geniohyoid, and genioglossus muscles is sectioned. The periosteum is then further elevated to the level of the gingival margin that is sectioned under direct vision through the oral cavity. The wide orocervical communication allows the surgeon to pull the tongue and floor of the mouth outward. With cancer approaching the tonsil, the tonsil must be included with the dissected specimen (Fig. 5.4). The resection then proceeds at the level of the vallecula, and the cancer of the tongue is resected with clear margins (Fig. 5.5). I do not include a total laryngectomy if the larynx is not involved, just to prevent aspiration. It is important to preserve the internal branch of the superior laryngeal nerve because it is essential for one of the most important larynx functions, airway protection against aspiration. After the completion of tumor resection, frozen section of the margins taken from the patient can be performed. The hyoid bone is usually preserved. If the preepiglottic space or other parts of the larynx are involved, a total laryngectomy is mandatory (Fig. 5.6).

Whenever the larynx is preserved, it is crucial to try to prevent aspiration. Some surgeons advocate cricopharyngeal myotomy aiming to reduce the pharyngeal hold phase of swallowing. Another option is a laryngoplasty as proposed by Biller, for example, bilateral incisions at the lateral margins of the epiglottis, aryepiglottic folds, and arytenoids and interarytenoid space; suture of the mucosa in the midline, leaving just a small superior

FIGURE 5.2 A marginal, sagittal, segmental, or more extensive resection of the mandible is done with clear margins according to the size of macroscopic and radiologic evidence of tumor invasion.

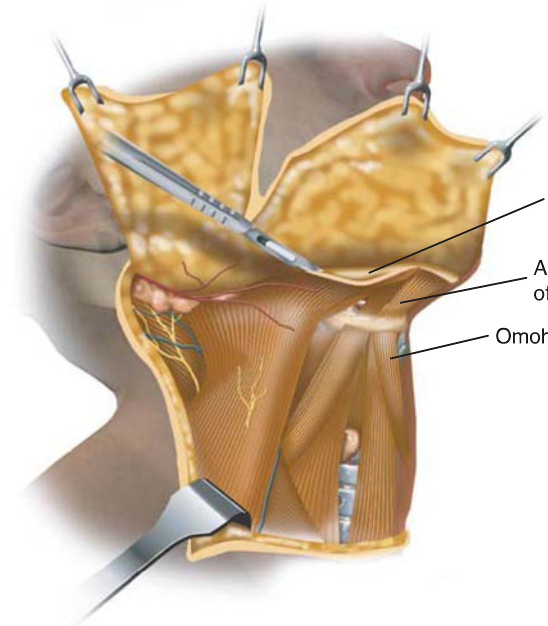


FIGURE 5.3
In the cases without mandible involvement, the superior flap is not raised, and a pull-through procedure is done. The periosteum of the mandible periosteum is incised along the inferior border of the mandible.

opening, sufficient for the patient to speak (Fig. 5.7). A permanent tracheostomy is always necessary. I use this technique only in patients at high risk of aspiration, such as older patients. Most of the time, a laryngeal suspension is sufficient to reduce the risk of aspiration, preserving the ability to speech and avoiding permanent tracheostomy (Fig. 5.8). The suspension is done on the side where the lateral wall of the pharynx was not resected. Usually three sutures are placed around the hyoid bone or through the thyroid cartilage and then through three holes in the mandible.

Total glossectomy results in significant functional and aesthetic defects. Reconstruction must be done immediately, and the main options are (osteo-) myocutaneous flaps and free flaps. I still use the pectoralis major myocutaneous flap because it provides a bulky amount of tissue and is reliable (Fig. 5.9). As an alternative for women to avoid mutilation of the breast, the latissimus dorsi flap may be used. The only disadvantage is that it is necessary to reposition the patient to harvest the flap. The surgical time is higher when a free flap is used; however, there are several options that can be customized to the patient's needs, and the rates of complications, hospital stay, and total costs are similar or even lower than the use of myocutaneous flaps. The main options are lateral thigh and rectus abdominis flaps. More recently, myocutaneous flaps are the preferred option only for patients whose clinical conditions are not favorable for microsurgical reconstruction.

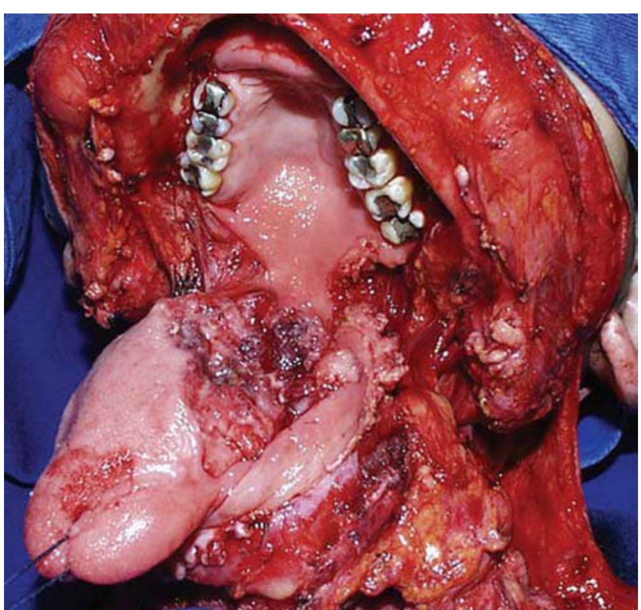


FIGURE 5.4
The periosteum is elevated up to the level of the gingival margin that is sectioned under direct vision through the oral cavity. The orocervical communication allows the surgeon to pull the tongue and floor of the mouth outward. Tumor that approaches the tonsil is included in the dissection area.

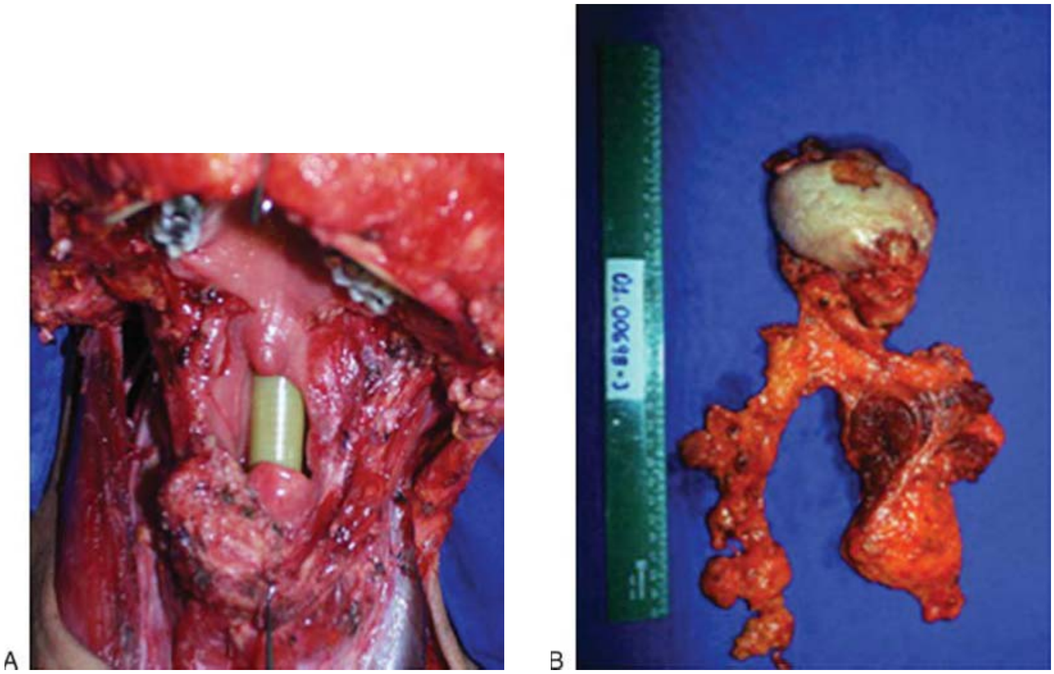


FIGURE 5.5
The tongue is resected with wide clear margins (**A**). The specimen contains the tongue and en bloc bilateral neck dissection (**B**).

Kamata et al. proposed a classification of the shape of the reconstructed tongue after subtotal or total glossectomy as protuberant, semiprotuberant, flat, or depressed. The functional outcomes were better in patients with protuberant and semiprotuberant flap shapes. The differences in speech intelligibility, food consistency, deglutition, and weight loss were all better and statistically significant. They suggested the use as a rectus abdominis free flap and laryngeal suspension in all patients.

POSTOPERATIVE CARE

The main immediate concerns in patients who underwent total glossectomy, bilateral neck dissection, and reconstruction not only are related to pain control, antibiotic prophylaxis, hydration, airway management, facial edema, wound care, and nutrition but also must consider the management of comorbidities such as diabetes, malnutrition, tobacco and alcohol withdrawal, depression, and anxiety.

The patient must be placed in a Fowler position in the recovery room and maintained for several days. This is considered mandatory to reduce gastroesophageal reflux, facial edema, and intracranial pressure (caused by simultaneous bilateral neck dissection). Early ambulation and sitting in a chair the day after the operation should be encouraged in an effort to reduce edema, risk of venous thrombosis, and clearing of tracheal secretions.

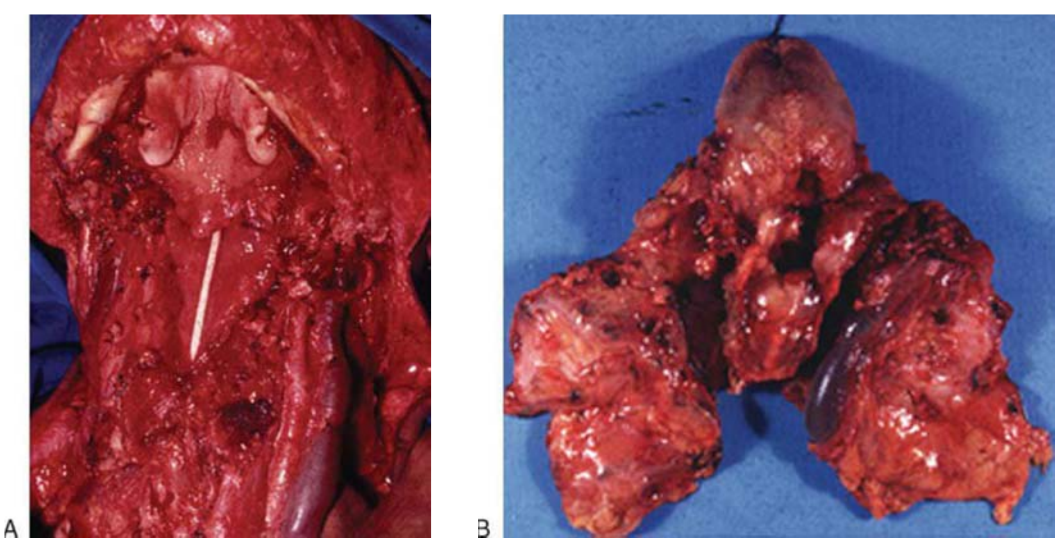


FIGURE 5.6
A: Total glossolaryngectomy.
B: The specimen contains the tongue, the larynx, and en bloc bilateral neck dissection.

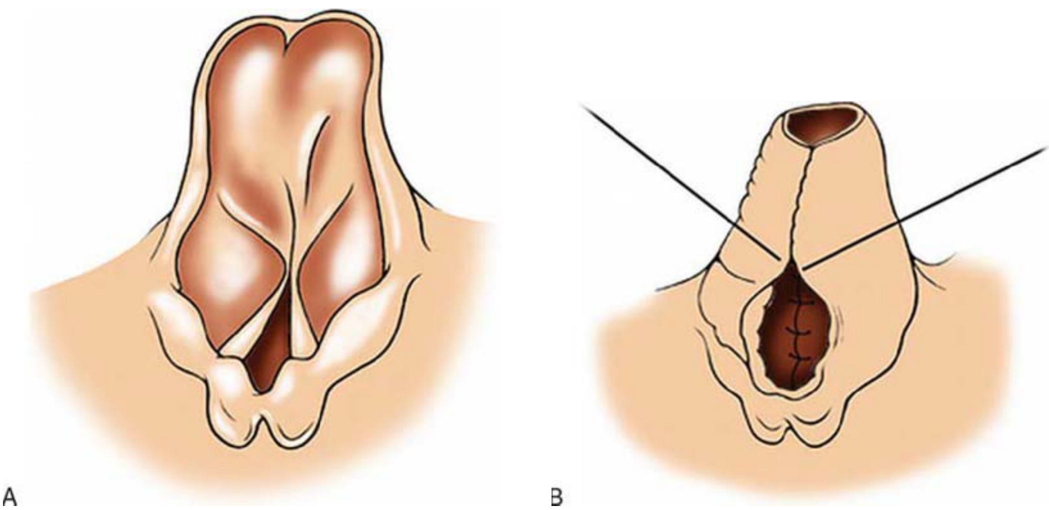


FIGURE 5.7
In some cases in which the larynx is preserved, **(A)** a laryngoplasty is included as proposed by Biller et al **(B)**.

Suctioning of the oral cavity and oropharynx is important to remove accumulated saliva and secretions that can cause aspiration and increase the risk of pulmonary infection. Frequent suctioning of the tracheostomy using clean technique must be done, and the patient has to be instructed to cough. An airway humidification system is necessary to prevent crusting, and the tracheostomy tube must be cleaned and changed frequently to avoid mucus plugs. The patient and family must be instructed as how to manage the tracheostomy because decannulation can take several weeks or may even be impossible. The suction catheters must remain in place usually for 5 or 6 days. The dressing must be changed daily, with attention to avoid compression at the site of flap pedicles.

A PEG is done only when long-term nutritional support is anticipated. For most patients, a nasogastric feeding tube is placed at the time of the surgical procedure, and it is maintained open to drain gastric fluids by gravity in order to reduce the risk of vomiting and aspiration. Feeding starts at the first or second postoperative day, or as soon as the patient exhibits gastrointestinal motility. In order to prevent dumping syndrome, small amounts of commercially prepared supplements are given the first day, and the quantity increases according to the patient's tolerance and needs. Water must be used at regular intervals for hydration and to clean the feeding tube. The tube is usually maintained for several weeks.

Patients submitted to a total glossectomy can no longer manage solid foods, but usually tolerate a soft or liquid diet. In order to improve the mechanism of swallowing after a total glossectomy, speech therapy under

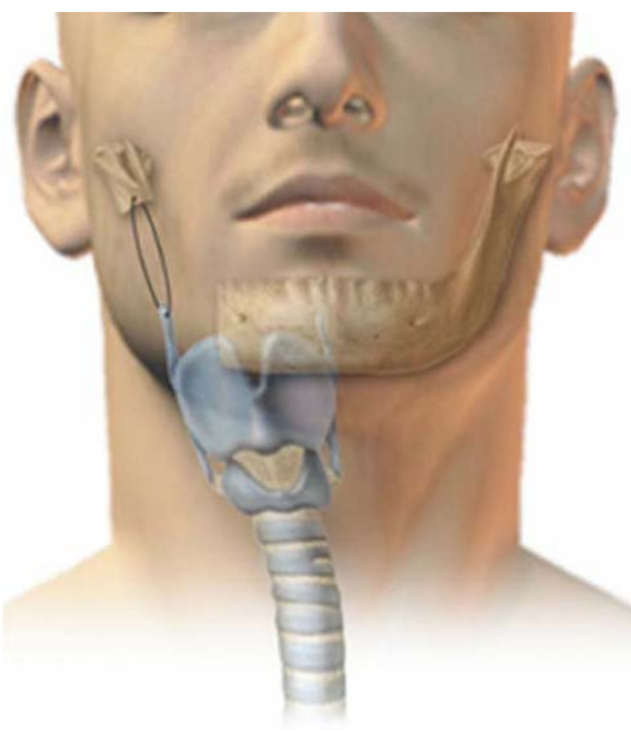
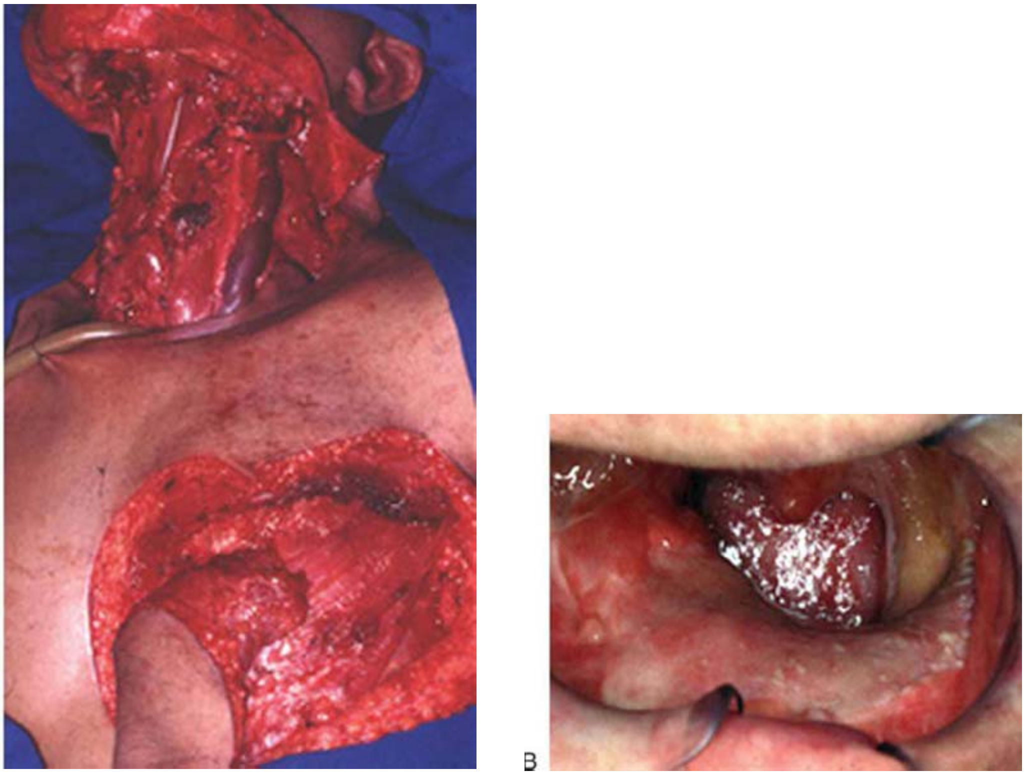


FIGURE 5.8
When the larynx is preserved, a laryngeal suspension is done laterally to the side where the lateral wall of the pharynx was not resected.



A B

FIGURE 5.9
A: A pectoralis major myocutaneous flap provides a bulky amount of tissue for reconstruction.
B: Final result of a patient who had a pectoralis major reconstruction.

the supervision of a trained therapist and preventive measures, including several surgical and nonsurgical techniques, have been described. Among them, the most frequent are augmentation prostheses, laryngeal suspension, the use of bulky free flaps, reinnervated (functional) flaps, and closure of the glottis.

COMPLICATIONS

The most frequent complications after total glossectomy are wound infection, flap necrosis, and buccocervical fistula. All patients require a tracheostomy for several weeks after the operation. Persistent aspiration occurs in 10% to 20% of the patients, and it delays tracheostomy decannulation and removal of the feeding tube, as well as increases the risk of pulmonary infection. The degree of aspiration is rarely significant enough to require a total laryngectomy and is usually improved with swallowing rehabilitation.

Dysphagia and speech disabilities are natural consequences of total glossectomy. The severity of these sequelae depends upon the extent of resection, type of reconstruction, patient's motivation, and capacity of adapting. Patients can no longer swallow solid food, but can use soft and liquid diet after swallowing therapy. In a small series of patients with total glossectomy with laryngeal preservation, we have documented increased transit times and stasis of food in the oral cavity and pharynx and superior esophageal sphincter. A few patients presented moderate and asymptomatic aspiration. All had swallowing compensations through increased buccal, mandibular, pharyngeal, and laryngeal activity and voluntary protection of the larynx during swallowing. In some patients, speech can be seriously handicapped, but most patients who underwent total glossectomy develop satisfactory speech.

RESULTS

Total glossectomy is still viewed as a heroic procedure of last resort or an unacceptable mutilation. In fact it remains a challenge because of associated early morbidity and sometimes delayed poor cosmetic, functional, and quality-of-life outcomes. However, with several recent advances in reconstruction techniques, mainly with free flaps, and swallowing and speech rehabilitation, total glossectomy has become an acceptable approach in selected patients. Furthermore, the overall survival rates reported by most other surgical series have shown survival rates over 20% to 25% in 5 years, which is superior to primary radiation or radiochemotherapy.

Barry et al. published the largest series of total glossectomies. A total of 109 patients were reviewed; most of them were submitted to a total glossectomy with laryngeal preservation. Overall survival reported was 32%

in 3 years and 21% in 5 years. Such rates were higher in the primary resection than in the salvage group (43% vs. 23% in 3 years and 23% vs. 16% in 5 years). In a series with 20 patients, Bova et al. showed a 5-year disease-specific survival of 38%. Van Lierop et al. reported eight patients submitted to total glossectomy, with or without laryngectomy, showing overall 3- and 5-year survival rates of 38% and 25%, respectively. Yanai et al. reported a 4-year disease-specific survival of 64% in patients submitted to a total or subtotal glossectomy. They also reported a rate of 83% of acceptable speech and swallowing capacities after treatment. Only 3 out of 20 patients were dependent on a feeding tube. Magrin et al. reported a series of 106 patients submitted to major glossectomy, and just 8% had significant persistent aspiration for more than 30 days, and a total laryngectomy due to aspiration was necessary in just one patient. The 5-year overall survival rates of 45% for T3 and 18% for T4 tumors.

PEARLS

- A total glossectomy can be performed with acceptable complication rates, and the preservation of the larynx does not significantly preclude functional swallowing.
- A total glossectomy without laryngectomy can be indicated as first-line and as salvage treatment for eligible patients.
- The treatment planning must be done by a tumor board using unbiased and evidence-based information, considering all significant factors, treatment options and risks, and possible outcomes.
- Good communication with patient and family is fundamental to success.
- En bloc neck dissection with radical resection of the primary tumor with clear margins is the mainstay of treatment.
- Laryngeal suspension, bulky flap, and early swallowing training under supervision are essential to improve functional outcomes.
- Postoperative radiotherapy or radiochemotherapy should be included as a routine for all patients undergoing total glossectomy, including the oropharynx in the portal.
- The 5-year survival of 25% or higher is acceptable for this particular population with advanced cancer.
- Patient motivation, family support, and experienced medical and rehabilitation teams are essential to improve quality of life after total glossectomy.
- Most survivors accept the sequelae after a total glossectomy.

PITFALLS

- The reported experience with total glossectomy is limited to single-institution retrospective series.
- The reported results usually combine patients who underwent primary and salvage total glossectomy.
- Not all tumors suitable for total glossectomy are diagnosed in patients who can be operated.
- The surgical risk is higher in older patients and in salvage procedures.
- Although the rehabilitation after total glossectomy is largely dependent on surgical technique, the expertise of the rehabilitation team, patient motivation, and family support are all important to achieve better functional outcomes.

INSTRUMENTS TO HAVE AVAILABLE

- Head and neck soft tissue tray
- Spatula and needle tip cautery, extended length tip also useful for distal vallecula cuts
- Head light
- Dental extraction set
- Cottonoids with Afrin

SUGGESTED READING

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6 TRANSORAL INFERIOR MAXILLECTOMY

Paul J. Donald

INTRODUCTION

The inferior maxillectomy is an operation usually employed in the management of malignant tumors that occur below Ohngrens line. The most common cancer is adenocarcinoma of salivary gland origin, followed by squamous cell carcinoma, acinic cell carcinoma, mucoepidermoid carcinoma, and adenoid cystic carcinoma. Less common are malignant melanoma, neuroendocrine tumors, and plasmacytoma. Cancer that invades the maxillary sinus from the oral cavity, primarily from the alveolar ridge or the hard palate, is often accessible to extirpation using an inferior maxillectomy. Mention must be made of one of the most malignant tumors seen arising from the minor salivary glands in the palate, the polymorphous low-grade adenocarcinoma, which is anything but low grade in its behavior. Fortunately, it is rare, but its aggressive behavior belies its bland-appearing histology. The advantage of inferior maxillectomy over the standard radical maxillectomy is that it can be done entirely intraorally and should not disturb form or function. If there is an intranasal component to the cancer, this can be managed with either a facial degloving procedure or a separate transfacial alotomy. The alotomy is an exposure of the anterior nasal cavity by incising around the nasal ala down to the underlying pyriform rim, through the nasal mucosa and vestibular skin, and retracting the ala medially.

HISTORY

Like so many malignancies of the upper aerodigestive track, cancers of the nasal cavity and paranasal sinuses begin with subtle symptomatology. Repeated episodes of mild epistaxis may be the presenting symptom. Unilateral purulent nasal drainage may arise from obstruction of the natural ostium of the sinus. Unilateral nasal obstruction usually begins as a subtle change barely noticed by the patient. Large cancers may invade the medial wall of the maxillary sinus or extend from the sinus ostium producing nasal obstruction. Cancers of the palate and alveolar ridge are much easier to detect by the patient in the earlier stages. Cancer of the palate may be the cause of an ill-fitting denture or may ulcerate early in its course causing pain and bleeding. Cancer arising in the alveolar ridge may cause loosening of a tooth/teeth. Their heaped-up character seen on inspection may be thought in the early stages to be due to periodontal disease. Squamous cell carcinoma of the alveolar ridge may initially present as a “dry socket” after tooth extraction or as an extraction site that produces what may appear to be granulation tissue but does not heal.

Among the most insidious of squamous cell carcinomas are those affecting the nasal vestibule. They often present as a small ulcer in the anterior floor of the nose and/or nasal septum. They have a marked tendency to spread posteriorly along the floor of the nose. It is often shocking to see how far posteriorly these cancers will spread along the periosteum of the pre- and central maxilla.

PHYSICAL EXAMINATION

Cancer of the inferior aspect of the maxillary sinus may remain asymptomatic for a long time before it manifests itself. The cancer may present as a mass or swelling of the alveolar ridge or hard palate, often covered by normal appearing mucosa. An ill-fitting denture or change in occlusion in the dentulous patient may be the only symptom. As the cancer enlarges, the mucosal surface may ulcerate and eventually result in an oral nasal or antral fistula causing nasal regurgitation of ingested liquids and even food. Numbness of the face due to invasion of the infraorbital nerve or orbital symptoms is rarely seen in cancers confined to the inferior aspect of the maxilla.

As always, a complete examination of the head and neck is mandated. Examination of the oral cavity may reveal a mass extending from the floor of the maxillary sinus to the alveolar ridge or palate. Cancers primary in the palate may also present as a mucosal covered mass, especially in the case of a benign tumor such as a pleomorphic adenoma or simply as an ulcer that is more common in malignancy. Cancers of the maxillary alveolar ridge may appear as a heaped-up lesion in an empty tooth socket or heaped-up tissue in the gingival collar around a tooth with or without ulceration or, in an edentulous area, as a mass. Examination of the nose may reveal a pink or red irregular mass often with an ulcer that bleeds when touched. Cancer of the nasal vestibule presents as a nodule and/or ulceration in the vestibular skin usually invading the adjacent musculature of the upper lip. This cancer unlike those that arise from the sinuses and present in the nasal cavity is often tender to the touch.

Thorough examination of the neck is vital with special attention to the submandibular triangle where the first echelon of lymph nodes related to the oral cavity is located.

INDICATIONS

The principal indication for inferior maxillectomy is the removal of either benign or malignant tumors. Pleomorphic adenoma is the most frequently encountered benign tumor of the hard palate. The vast majority of these tumors simply require a local resection of the tumor with a narrow margin of healthy tissue. Any bone loss probably results from tumor necrosis, so a light drilling of the adjacent bone is all that is required for complete excision. Even more common than the pleomorphic adenoma is the osteoma of the hard palate that carries the name of torus palatinus. These rarely require excision. The usual indication is to accommodate a denture. A rare benign tumor of the palate, the fibrous myxoma, may require a limited palatectomy and limited inferior maxillectomy. Ameloblastomas are classified as benign tumors of odontogenic origin. Their benign designation is because of their lack of metastases. However, they are locally aggressive and must be resected with a safe margin of healthy tissue. When originating in the maxillary alveolar ridge, adequate resection may require an inferior maxillectomy. A large odontogenic keratocyst of the maxillary alveolus may also require an inferior maxillectomy for adequate clearance. These like the ameloblastoma have frequent local recurrences and need an adequate margin of healthy tissue around the tumor.

The list of various malignant tumors taking origin in the palate and floor of the maxillary sinus is described in the Introduction section with adenocarcinoma and squamous cell carcinomas comprising the majority of malignancies below Ohngrens line.

Another indication for inferior maxillectomy is osteomyelitis. This sometimes is induced by irradiation therapy usually following tooth extractions with or without accompanying infection. Another cause of osteomyelitis of the maxilla that appears to be becoming more common is a complication of taking bisphosphonates. Other infections may be responsible for maxillary osteomyelitis such as actinomycosis. Patients who are on immune suppression or on chemotherapy for leukemia or lymphoma or suffer from HIV/AIDS may require inferior maxillectomy if the hard palate or alveolar ridge becomes nonviable. Chronic conditions such as chronic sclerosing osteomyelitis, which may accompany Romberg disease, may require a conservative type of inferior maxillectomy.

Cervical metastases from cancer originating in the hard and soft palate that would be limited enough to be appropriately treated by inferior maxillectomy are uncommon and are even more unusual with carcinomas originating in the maxillary sinus below Ohngren line. Cancers arising in the hard palate are less likely to metastasize than those taking origin in the soft palate. Soft palate cancers, when they do metastasize, are often bilateral. Cancers in the maxillary sinus metastasize uncommonly, but when they do, they have a different route than those from the palate. Some of the lymphatic radicals drain to the high retropharyngeal nodes and, unless quite large, are difficult to detect on direct clinical examination. CT and MRI scanning are necessary to rule out metastatic cancer at this site. The appearance of metastatic nodes in later follow-up, however, is much more prevalent in palatal malignancies than when these patients first present.

Selective neck dissection is generally not done in the limited cancers described here. The role of selective neck dissection or sentinel lymph node studies is controversial in mucosal melanoma originating in these sites. Modified radical neck dissection of Levels I through V is reserved for those cancers with clinically positive lymph nodes. The addition of retropharyngeal nodal dissection is done in those patients whose primary cancer arose in the maxillary sinus. Treatment with postoperative adjuvant radiation therapy combined with chemotherapy is employed when there is multiple adenopathy, or extracapsular spread or perineural or perivascular spread of the primary cancer.

Editorial Comment

The incidence of occult metastasis from squamous cell carcinoma of the hard palate and maxillary alveolar ridge has not been studied systematically; however, recently several series have been published on the actual incidence of cervical metastasis from these individual subsites. Although the metastatic rate is generally perceived to be low, our own retrospective study published in 2006 indicated that the overall incidence of metastasis to the cervical lymph nodes from squamous cell carcinoma of the hard palate and maxillary alveolar ridge is significant (34.6%). Elective neck dissection may be offered to patients with cancer of the hard palate and alveolar ridge who have an N0 neck, affording the patient and the surgical team the valuable histologic information needed to guide adjuvant therapy. This will reduce the potential need for future hospitalization and morbidity from radical therapies when the neck is not treated in patients with cancer of these sites. Our data suggest that the behavior of the squamous cell carcinoma of the hard palate and alveolar ridge is similar to that of other sites in the oral cavity such as the tongue and floor of the mouth.

Brown et al., in a recent study concluded that squamous cell carcinoma arising in the maxillary alveolus and hard palate has a similar risk for regional metastasis as the rest of the oral cavity, and the lower propensity for elective neck dissection is resulting in higher regional recurrence and lower survival rates. Future management of the N0 neck for patients with squamous cell carcinoma of the maxillary alveolus and hard palate should include the same approach to the neck as in patients with squamous cell carcinoma in other sites in the oral cavity because the risk is equivalent.

Morris et al. studied the incidence of metastasis to the lymph nodes in the neck from squamous cell cancers arising in the hard palate and maxillary alveolus in order to identify factors predictive of regional failure. Their series included 139 patients with squamous cell carcinoma from these primary sites. None of the necks were treated electively. Regional failure occurred in 28.4% of these patients and was significantly associated with pathologic T classification, ranging from 18.7% (pT) to 37.39% (pT4). Most patients (65.6%) with regional recurrence were not able to be salvaged. Thirty-two of the patients (29.5%) who were N0 at presentation had recurrence in the neck. Therefore, it would seem justified to recommend elective neck dissection for the majority of these cancers due to three factors: (1) the high rate of regional recurrence; (2) the limited number of salvageable recurrences; and (3) the poor outcome despite salvage.

Montes et al. reported a series of 146 patients with squamous cancer of the oral cavity. The regional metastatic rate was 31.4%. The regional salvage rate was 52.9%. Surgeons contributing patients to this multicenter study recommend a selective neck dissection of levels I–III as a primary management strategy for patients with T2, T3, and T4 squamous cell cancer of the oral cavity.

CONTRAINDICATIONS

Distant metastasis is a contraindication to inferior maxillectomy. Lack of physical fitness and lack of patient cooperation are also contraindications to surgery. Invasion into the floor of the orbit or invasion of the infraorbital nerve precludes inferior maxillectomy. These patients need more extended resections.

Patients on anticoagulant therapy should discontinue their medication and go on bridging therapy so that they can be reversed at the time of surgery. Patients with severe comorbidities must have their condition optimized prior to surgery.

Prosthetic rehabilitation is essential, and in those instances where some form of dental rehabilitation is not available to the patients, they should be well aware of nasal regurgitation as well as difficult swallowing and speaking.

Invasion of the pterygoid muscle requires a wider exposure than obtainable by inferior maxillectomy, so that total maxillectomy would be a better surgical option.

PREOPERATIVE PLANNING

Imaging Studies

The most valuable imaging study is the CT scan of the sinuses. The scan will demonstrate a mass often accompanied by bone erosion, and examination of the neck is important. Sorting out whether an opacification in one or more sinuses is tumor or retained secretions is better done with MR scanning.

Pathology

Incisional biopsy of a mass in the palate, nasal vestibule, or alveolar ridge will usually reveal the diagnosis. Masses confined to the maxillary sinus will usually be accessible by endoscopic examination and biopsy. A small trephine opening in the anterior wall of the sinus or a limited Caldwell-Luc procedure will provide

excellent access to the sinus cavity for biopsy. If a biopsy or surgery has been done elsewhere, the slides must be acquired and be reviewed by a head and neck pathologist prior to surgery.

Maxillofacial Prosthodontics

It is essential for patients to have a consultation with a maxillofacial prosthodontist prior to surgery. The insertion of a prosthetic device at the time of surgery is essential for early rehabilitation. The ability of the patient to speak and take fluids by mouth in the early postoperative period without significant nasal regurgitation facilitates an early recovery from the surgery.

SURGICAL TECHNIQUE

At the time of surgery, cocaine-soaked pledgets or cottonoids are placed within the nose to help with hemostasis. Xylocaine with epinephrine 1/100,000 is injected in the gingival–buccal sulcus bilaterally for the same purpose. A pack is placed in the throat to prevent the passage of blood into the stomach. Betadine-soaked sponges are placed in the oral cavity to help with sterility. After induction of general anesthesia, oral intubation is usually done with a right-angled tube such as an oral RAE® tracheal tube to move the anesthetic connecting tubes away from the surgical field. A Hibb's pack of 1-inch ribbon gauze soaked in Xylocaine with 1/100,000 epinephrine is prepared ahead of time to be placed into the maxillectomy cavity to ensure hemostasis at the end of the resection.

Inferior Maxillectomy

A Pierce retractor is used to retract the upper lip to expose the gingival–buccal sulcus adjacent to the maxilla. An incision is made just above the sulcus with either a no. 15 blade or a needle point Bovie (Fig. 6.1). A tooth in the upper arch anteriorly, usually the canine, is extracted. The incision is carried down through the periosteum onto the bone of the maxilla. The periosteum and overlying soft tissue are elevated up to the level of the infraorbital nerve taking great care not to injure it. Penetration of bone by cancer and extension into the overlying soft tissues require taking a generous cuff of soft tissue around that which is involved with the cancer. If cancer extends close to the overlying skin, a biopsy of the subcutaneous tissue closest to the soft tissue penetration of the cancer will dictate whether overlying skin must be resected. Only on rare occasion will a patient have penetration of the skin with cancer limited to the inferior maxilla. The majority of patients with penetration of the skin will need a total maxillectomy in addition to excision of the skin. The extent of the cancer as determined by the preoperative imaging and physical examination will provide some idea of the extent of the resection. However, only when the cancer is exposed at the time of surgery will the true extent of the operation be determined.

FIGURE 6.1
Intraoral incision for inferior maxillectomy.

Elevation of the periosteum is continued lateral and posterior as far as the maxillary tuberosity, staying inferior to the level of the pterygoid plates. Medially the elevation continues to the rim of the pyriform aperture. The extent of the elevation is determined by the extent of the cancer. The amount of involvement of the medial wall of the maxilla will dictate the extent of resection of the lateral nasal wall. Often the superior extent of resection will not be necessary any further than the emergence of the inferior turbinate from the lateral nasal wall. Occasionally the floor of the nose is involved, and the mucosa of the floor as well as the underlying bone must be removed together with the adjacent inferior nasal septum.

The width of the resection of the palate will be determined by the degree of penetration by the cancer into the floor of the maxillary sinus. Resection of the cancer that has breached the mucoperiosteum of the palate and now presents in the oral cavity must include a wide margin of healthy tissue. The most common site of penetration of cancer into the floor of the maxillary antrum is from the maxillary alveolus. However, most cancers requiring an inferior maxillectomy will begin in the hard palate. In the cases of cancer originating in the floor of the maxillary sinus, much of the palatal mucoperiosteum can be preserved. The bone excision is often wider than the mucosal resection, and the residual mucoperiosteum can be placed across the margin of the residual palatal bone and into the defect. Selected biopsies for frozen section must be taken to ensure that preservation of the residual soft tissue of the palate is safe.

The bone-cutting needle is used to make the osteotomy that will horizontally transect the anterior wall of the maxilla (Fig. 6.2). A small opening is made in the inferior aspect of the anterior wall of the sinus to establish the extent of the cancer by direct visualization. The osteotomy continues as far as the maxillary tuberosity and through it if there is involvement of the sinus posteriorly. Anteriorly the osteotomy of the maxillary alveolus is placed as close to the tumor as is safe. Subsequent prosthetic rehabilitation becomes increasingly difficult as resection progresses medially around the anterior arch. The alveolar osteotomy progresses onto and around the involvement of the floor of the maxillary sinus. The palatal osteotomies usually involve resecting more of the palatal bone than soft tissue of the hard palate (Fig. 6.3). When the medial wall of the maxilla and/or nasal floor is invaded, then an osteotomy of the pyriform rim and the floor of the nose is made, which establishes the anteromedial margin (Fig. 6.4). The osteotomy in the pyriform rim is made as inferiorly on the nasal bone as possible such that subsequent support of the nasal ala is not lost.

The specimen can then be removed (Fig. 6.5) and a Hibb's pack inserted to ensure hemostasis. Once the bleeding is controlled, the raw soft tissue of the cheek is resurfaced with a split-thickness skin graft and quilted into place. Residual mucoperiosteum of the palate is advanced into the defect and secured in place with sutures. A pack of iodoform gauze is placed in the cavity and the previously fashioned surgical splint fitted into place and fixed with a lag screw into the residual hard palate. The pack is removed in 7 to 10 days preferably under general anesthesia.

FIGURE 6.2 Osteotomy along the anterior wall of the maxilla.

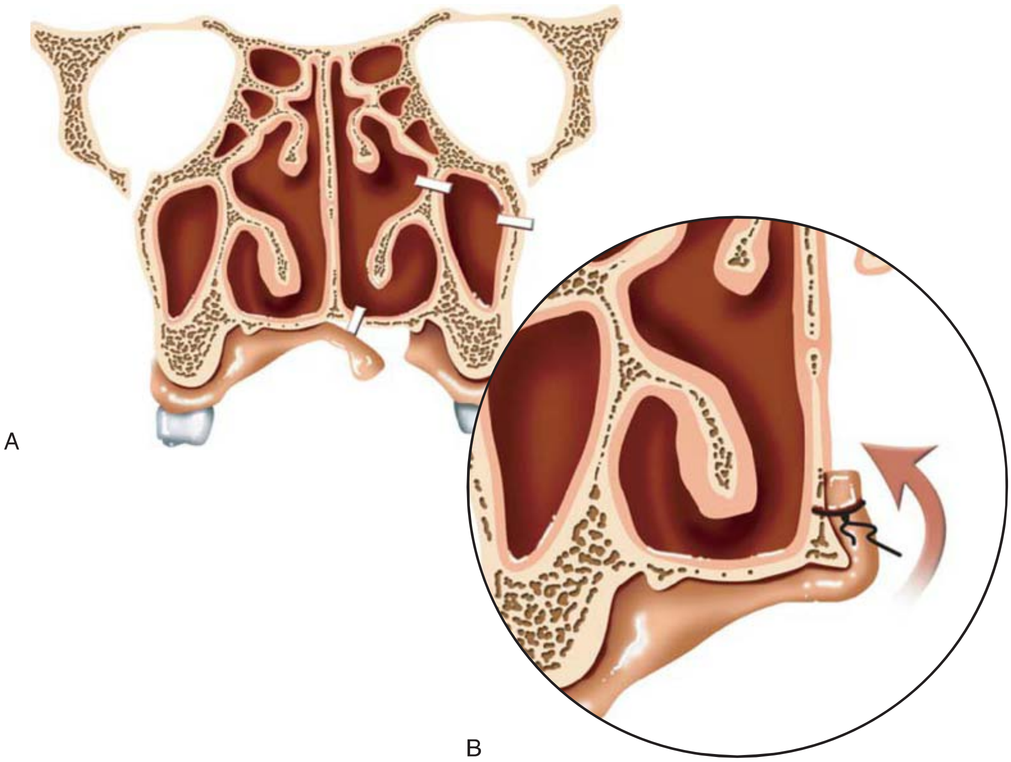


FIGURE 6.3
A: Palatal mucoperiosteal flap created during inferior maxillectomy. **B:** Palatal flap turned into defect.

Resection of the Alveolar Ridge

When the cancer arises from the alveolar ridge or palate, the limits of resection are easier to determine. In most tumors, a 1.5- to 2-cm margin of healthy tissue is required for safe resection. A narrower margin can be employed when the cancer is a low-grade mucoepidermoid carcinoma. A wider margin is necessary in the removal of a mucosal melanoma or a low-grade polymorphous adenocarcinoma. In general, the soft tissue margin is necessarily wider than that of bone because of the invasion patterns in the two tissues, with the density of

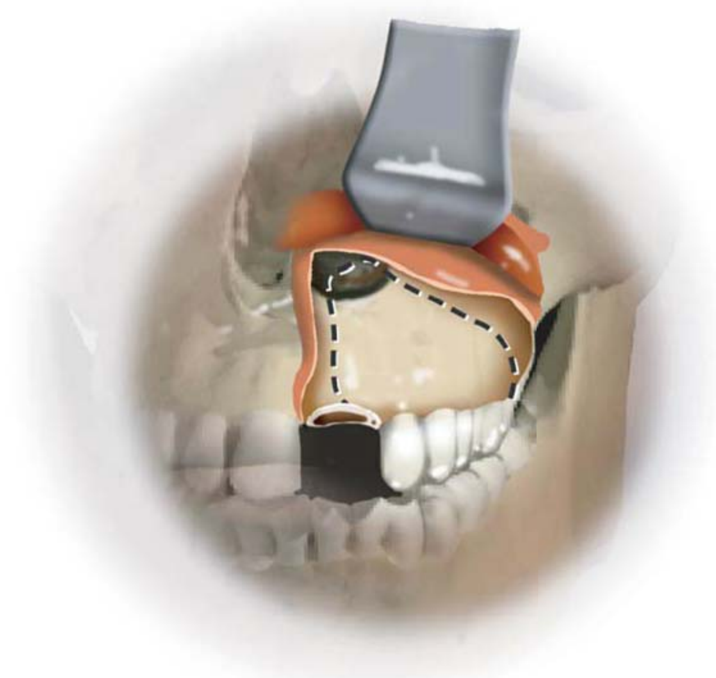


FIGURE 6.4
Lines of resection through pyriform rim, nasal floor, and anterior maxillary alveolus.

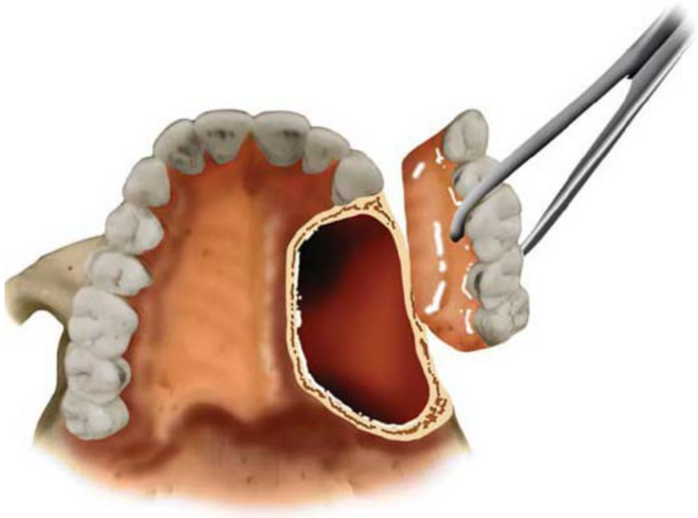


FIGURE 6.5 Inferior maxillary specimen being removed.

bone being harder to penetrate than that of soft tissue. This applies mainly to cortical bone and not cancellous bone where the spread is facilitated by the presence of soft connective tissue and blood vessels.

In the management of cancer of the maxillary alveolus, the teeth in the field of tumor invasion are included in the bloc. The incision in the adjacent gingival buccal sulcus is more limited unless there is radiographic evidence of invasion of the maxillary sinus wide of the obvious tumor in the alveolar ridge. The tooth on each side of those with obvious invasion is extracted. Care is taken to protect the lamina dura of those teeth adjacent to the extraction sites to maintain their viability for future use in stabilizing the denture. Curettings of the cancellous bone at the margins of resection are sent for frozen section to establish adequacy of the resection. Incision of the soft tissue of the adjacent palate continues over the fixed gingiva through the extraction sites of the uninvolved teeth that were extracted to establish tumor-free margins through the unfixed gingiva, to the region of the gingival–buccal sulcus. The osteotomy through the bone deep to the soft tissue is made with the B1 cutting needle of the Midas Rex drill. Vertical osteotomies in the alveolar ridge are made through the sockets of the previously extracted teeth through the side of the socket closest to the cancer. This bone is obviously thicker than the bone of the anterior wall of the maxilla or that of the hard palate. Horizontal osteotomies are made into the anterior wall of the maxilla about midway between the infraorbital nerve and the floor of the maxillary sinus. The anterior limit of the resection may be lateral to the pyriform rim of the nasal skeleton and, if so, the second vertical osteotomy is made at that point. If tumor extends medially to the pyriform rim, then the nasal floor must be removed as described above. When the cancer is confined to the alveolar ridge with minimal invasion of the floor of the maxillary sinus, then a small portion of the hard palate is taken in order to establish an adequate resection margin (Fig. 6.6). The cancer is then removed en bloc.

If the defect in the bone is small and the patient edentulous, then the patient's own denture is fixed in place with a lag screw through the denture into the palate and adjacent alveolar bone. If the patient has intact dentition, then a previously fashioned surgical obturator is clipped to the adjacent teeth and fixed with a lag screw. An attempt to close the defect by advancing a flap of buccal mucosa may be made but is usually unsuccessful in larger defects because there will be no lining with vascularized tissue over the raw surface of the flap that faces the maxillary sinus. Conversely, a rotation flap of palatal mucoperiosteum can be constructed to cross the defect. This tissue is highly inflexible, so that a large flap is required to close a relatively small defect. The donor site is left to heal by second intention. If a larger defect would require a combination of a buccal mucosal flap and a palatal flap, the suture line thus created will usually be located at the center of the defect and the repair is doomed to fail. In small defects, even if there is only partial take of the flap the defect often closes down in time by cicatricial scarring so that the resulting fistula scars in completely or shrinks to a size that is asymptomatic.

Palatectomy

Cancers of the palate are usually excised with a margin of 1 to 2 cm, depending on their histologic type. The bone of the floor of the nose and the attached mucosa as well as that of the adjacent maxillary sinus will be removed en bloc with the palate. When outlining the palatal resection, a margin of bone wider than that of soft tissue is to be removed to facilitate the transposition of the mucoperiosteal palatal flap through the bony gap. This will provide a stout lining through which the surgical obturator will be inserted at the end of the case. It is wise to leave the palatal eventration open, closing the gap with a surgical obturator rather than interposition of a flap. This enables close scrutiny of the margins of resection such that early local recurrences can be detected. The osteotomies through the alveolar ridge are made only if the fixed gingiva is invaded by the cancer in the

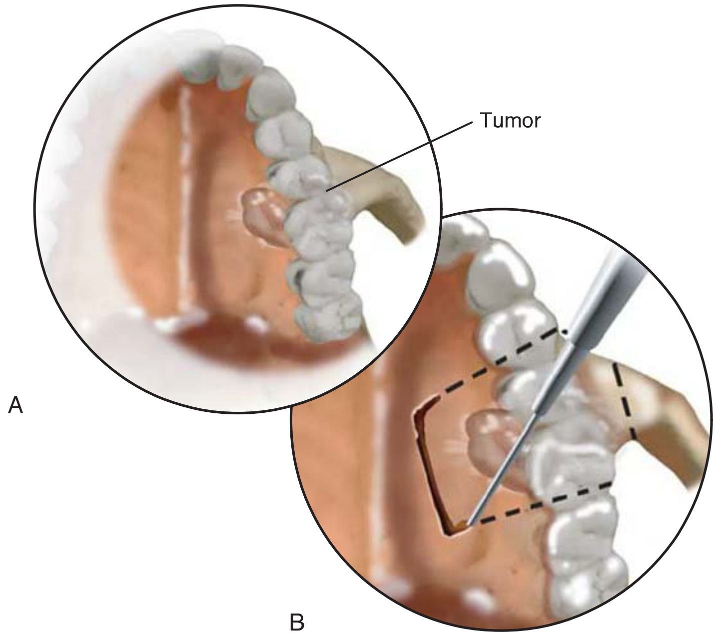


FIGURE 6.6
Osteotomy for alveolectomy.

adjacent palate. The osteotomies along the face of the maxilla are similar to those used in cancers of the alveolar ridge. Otherwise, only the involved mucoperiosteum of the palate and the underlying bone are incised. If cancer crosses the midline of the palate, then an intranasal approach is used to cut both the mucoperichondrium and mucoperiosteum of the inferior septum just above the maxillary crest. A horizontal osteotomy is made and then directed inferiorly at the sites of the underlying palatal incisions posteriorly and anteriorly (Fig. 6.7). The block is then removed. Closure is similar to that described for the alveolar resection except if the septum is transected. In those cases the septal skeletal elements are trimmed superiorly, sufficient to allow the suturing of the septal mucoperiosteal flaps without tension. Radial forearm and scapular free flaps are increasingly being used to close defects after maxillectomy when a considerable amount of full-thickness hard palate has been removed. The major problem when these flaps are used is that they may cover up a local recurrence that is often, when small, not apparent on MRI, CT, or PET scans. In addition, many prosthodontists have problems rehabilitating such patients with a denture. The skin also has a much different texture than that of the acrylic of the denture and is repugnant to some patients.

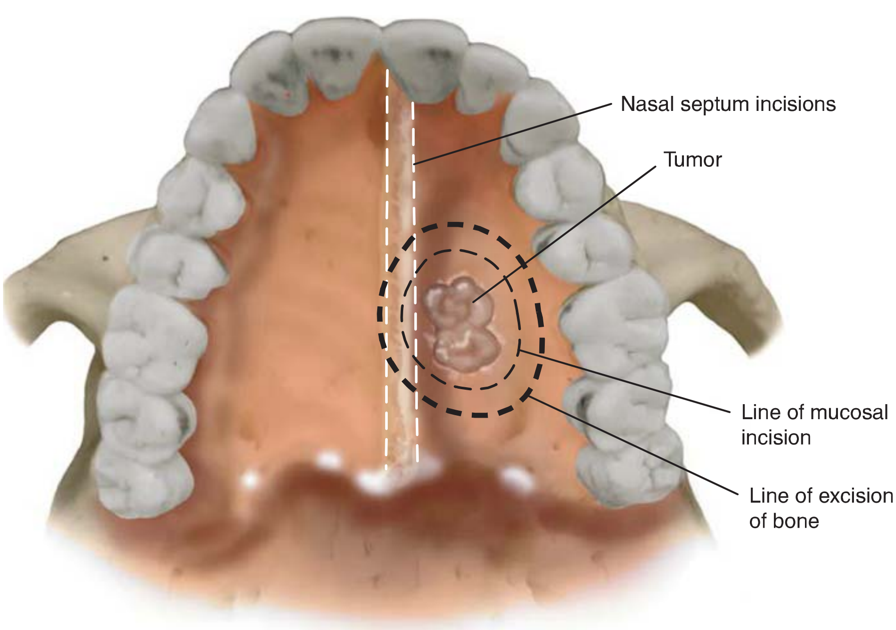


FIGURE 6.7
Partial palatectomy for palatal malignancy.

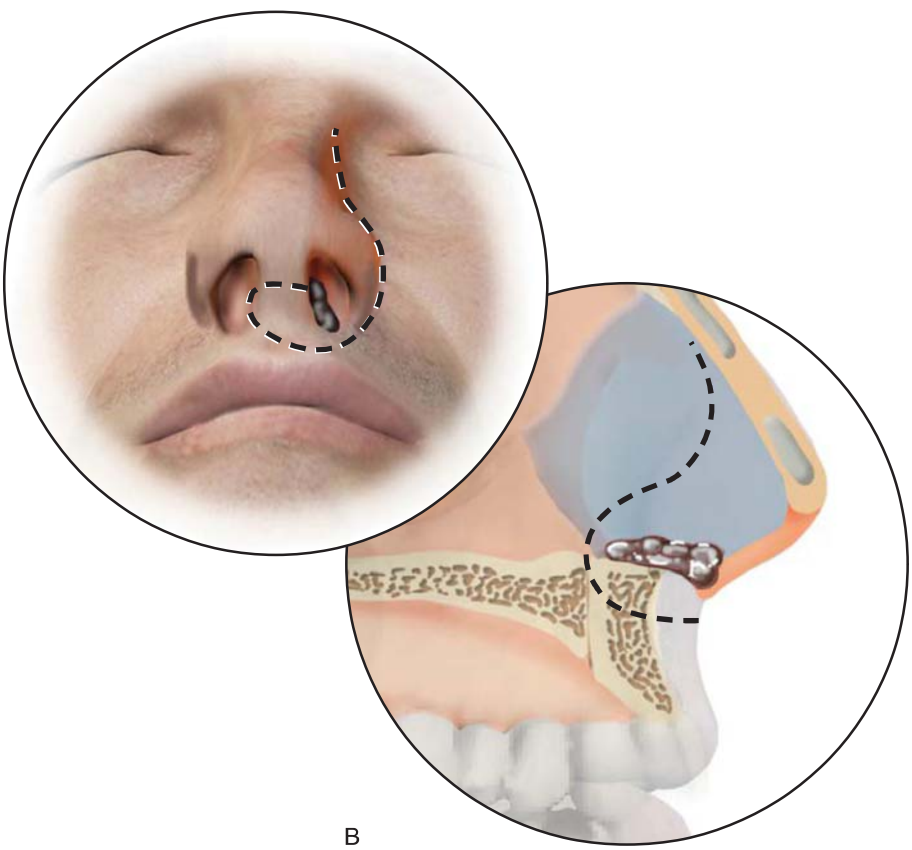
Premaxillectomy

A variation on the inferior maxillectomy is employed for cancers arising in the nasal vestibule. Many of these cancers not only invade the nasal septum and nasal columella but have the unfortunate propensity of invading posteriorly along the nasal floor. The route of spread is usually along the periosteum of the floor; however, the mucosa itself may look uninvolved. CT scanning and dental films will not reveal early bone invasion. By the time erosion is obvious, the invasion of the bone is usually extensive. The presence of cancer of the nasal vestibule usually requires resection of the premaxilla. This often means the entire primary palate as well as the floor of the nose need to be excised.

In resecting a cancer of the nasal vestibule, the interior of the nose is cocainized, and the nasal septum and floor of the nose are injected with xylocaine and epinephrine. The palate and sometimes the upper lip and nasal tip are similarly injected to aid in hemostasis. The area of resection is drawn with methylene blue and usually at a minimum includes the columella, adjacent septum, and some of the upper lip. Part or all of the primary palate is marked out. The mucoperiosteum of the palate corresponding to the floor of the nose can often be spared especially if there is no radiographic evidence of bone erosion. If the patient has intact anterior upper dentition, then the teeth at the sites of the osteotomies in the alveolar ridge are extracted.

The incision starts at the superior aspect of the nasal facial crease up against the nasal ala as in a classical alotomy. Clearance of visible and palpable cancer by a 1-cm margin of healthy tissue is usually sufficient. Sufficient septum, nasal tip, and lip are included in order to achieve cancer-free margins (Fig. 6.8). If minimal invasion of the floor of the nose is seen, then it may even be possible to save the central teeth and the adjacent inferior part of the alveolar process and just take the floor of the nose preserving the oral side mucoperiosteum. Preserving the central teeth when taking floor of the nose and nasal side of the central alveolar ridge usually will result in devitalizing these teeth, which will necessitate root canal treatment in the future. Most often, however, these teeth need to be excised along with the premaxilla. Usually the incision in the oral mucoperiosteum will be limited to the palatal side of the alveolar ridge but will be dictated by tumor extent. The remainder of the oral mucoperiosteum can usually be preserved. If the palatal bone is penetrated, the full thickness of the palate will need to be excised.

A bone-cutting needle such as the Midas Rex B1 or B5 is best suited to make the osteotomies. The central maxillary alveolus in continuity with the mucoperiosteum and attached bone of the nasal floor on both sides is removed. An incision along the nasal septum just above the maxillary crest is made through the septal



A

B

FIGURE 6.8
Outline of excision for premaxillectomy for cancer of the nasal vestibule.

mucoperiosteum of both sides of the nose, and then the bone and cartilage are incised horizontally at this same level leaving the crest attached to the central bony strip. The lateral osteotomies of the bone of the central nasal floor are made in the lateral wall of the nose through the inferior meatus into each of the maxillary sinuses. The excision of the bony floor ends posteriorly at the junction of the soft and hard palate. The soft palate at this site is dissected from the posterior edge of the central hard palates. Once freed from the oral side mucoperiosteum, the specimen can be removed.

Limited extension can be adequately resected through the defect created by the inferior maxillectomy and partial palatectomy. The pterygoid plates can be removed with a cutting bur and the pterygoid muscle extension by cross-clamping muscle removing cancer and suture ligature of the muscle stumps. The hope of en bloc excision of these advanced lesions is almost impossible so that the establishment of negative resection margins can only be accomplished by doing repeated frozen section and continuing the tumor removal in a “modified en bloc” method until all cancer-free margins are obtained.

Invasion of the infratemporal fossa is usually detected on preoperative imaging studies, and such cases will need a lateral approach such as that used in middle fossa/infratemporal approach added to their procedure. When invasion of the infraorbital nerve or the Vidian nerve is detected, dissection should be carried out to their respective foramina at the base of the skull and if positive then delayed to the future when a staged intracranial /extracranial resection can complete the tumor removal. Involvement of the Eustachian tube can be followed safely up to the point where the cartilaginous canal interdigitates with the bony canal. Further invasion necessitates a delayed skull base approach resection.

POSTOPERATIVE MANAGEMENT

A vast number of patients having an inferior maxillectomy do not need a tracheostomy, so airway care needs are minimal. Care is taken, however, to observe the patient for CO_2 narcosis because of the potential airway obstruction due to the nasal packing. In addition, obtundation may be aggravated by the use of narcotic medication for pain. Perioperative antibiotics are given on the day of surgery and continued through the first and second postoperative days. The patient should be encouraged to get out of bed the first postoperative day. Early ambulation and TED stockings are important to prevent thrombophlebitis and pulmonary embolism. A diet of clear to full liquids is ordered until the packing is removed at the 5th to 7th day postoperatively. In most cases, a surgical obturator has been placed at the time of surgery and anchored to the alveolar ridge by at least two bone screws. This aids the patient in eating and articulation. Attention to oral hygiene is important to prevent infection. The patient is usually discharged the day after the packing is removed.

COMPLICATIONS

Complications from inferior maxillectomy are infrequent. Postoperative bleeding may occur, and the patient must be returned to the operating theater for hemostasis. The most common vessels to be involved are the greater palatine artery and the branches of the internal maxillary artery. Problem bleeders can be embolized by the interventional radiologist. Infection is uncommon in the early postoperative period; however, the nasal packing usually becomes a bit odiferous in its last 2 to 3 days. There is no need for removal unless there is increasing pain, fever, or signs of impending sepsis. Patients need to be warned that some degree of facial and intraoral numbness is to be expected, and some will often clear in the few months following surgery. If any pterygoid musculature is resected at the same time of surgery, trismus is likely to ensue. Early intervention with exercises to increase jaw opening and the use of such devices as the Therabite may prevent this from being a permanent problem. Some postoperative nasal crusting is to be expected because of the removal of the inferior turbinates and inferior nasal septum.

- Bleeding usually from the internal maxillary artery
- Infection
- Facial numbness—usually over V2
- Nasal crusting
- Trismus
- Nasal regurgitation
- Rhinolalia aperta

RESULTS

There are very few studies of patients undergoing inferior maxillectomy for cancers limited to the inferior maxilla. Since the advent of the routine use of postoperative radiotherapy with or without chemotherapy, there

has been a vast improvement in survival rates of patients with cancer of the maxillary sinus in general. Those malignancies confined to the inferior maxilla are in the T1 to T2 range have the best survival rates.

Cancer of the inferior maxilla is often treated by surgery alone because of the localized nature of the disease. In an analysis by Dulguerov et al., of 220 patients with T1 and T2 carcinomas of the nasal cavity and paranasal sinuses, the 5-year actuarial survival was 91% and 64%, respectively. In the University of Arkansas series reported by Hana, the T1 and T2 tumor-free survival from all sinus tumor sites was 80%. One can infer from these data that inferior maxillectomy for malignancy has an excellent prognosis with adenocarcinoma doing better than squamous cell cancers.

Cancers limited to the hard palate are of the Stage I variety with survival rates varying to tumor type. Patients with squamous cell carcinoma have a 75% 5-year survival rate. Adenocarcinoma survival rates vary according to subtype with adenoid cystic cancers doing well early but with marked decrements at 10- and 15-year follow-up. In Conley's series, 79% of the patients were alive at 5 years and 33% at 15 years when treated with postoperative radiation therapy. This included all stages of cancer and not just those that had inferior maxillectomy. Polymorphous adenocarcinoma has a much worse prognosis. Mucosal melanoma similarly has a poor prognosis.

PEARLS

- If a biopsy was done elsewhere, have your pathologist review or take second biopsy.
- Leave sufficient buccal mucosa for closure.
- When resecting palatal bone, take more bone than palatal mucoperiosteum to aid in comfort of the obturator after closure.
- Avoid injury to the infraorbital nerve during anterior maxillary resection.
- Preserve the lamina dura over teeth adjacent to palatal osteotomies.
- When resecting cancer of the nasal vestibule, take wide bone margins in the floor of the nose.
- When resecting cancer of the sinus, go wider in mucosa than bone.
- Secure palatal obturator with screws after placing packing.

PITFALLS

- Not having a definitive diagnosis prior to surgery
- Not using cocaine for intranasal hemostasis
- Not placing a throat pack preoperatively
- Neglecting to take preoperative dental impressions for the surgical obturator
- Sacrificing adequate surgical margins for the sake of function and aesthetics
- Taking too little bone in cancer of the nasal vestibule

INSTRUMENTS TO HAVE AVAILABLE

- Standard instruments for open sinus surgery
- Dingman mouth gag
- Luc forceps
- Multitoothed grasping forceps
- Dental extractions set
- Midas Rex drill with B1 and B5 bone cutting needles and TAC attachment with small acorn burs
- Sagittal cutting saws

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7 TECHNIQUE OF TRANSORAL LASER MICROSURGERY FOR CARCINOMA OF THE BASE OF THE TONGUE

Guy J. Petruzzelli

INTRODUCTION

The base of the tongue (BOT) is bounded anteriorly by the circumvallate papillae extending inferiorly to the vallecula and includes the anatomic regions of the lingual tonsils, pharyngoepiglottic folds, glossoepiglottic folds and, laterally, the glossopalatine sulcus. Carcinoma of the tongue represents approximately 25% of all head and neck malignancies with malignancies of the BOT accounting for one-third of all tongue neoplasms. Malignancies of the BOT reflect the histologic and embryologic complexity of this region and include squamous cell carcinoma (SCC), minor salivary gland carcinoma, lymphoma, mesenchymal malignancies, and carcinoma arising in lingual thyroid (Table 7.1).

Optimal treatment of nonlymphoreticular malignancies of the tongue base remains controversial. Traditional open approaches to the BOT included composite jaw–tongue resection, lateral pharyngotomy, suprahyoid pharyngotomy, and either lateral or midline mandibulotomy. Common among these approaches is a breach of the oral–oropharyngeal mucosa with concomitant salivary contamination of the neck, increased surgical morbidity, poorer functional outcomes, and the potential need for microvascular reconstruction of complex oropharyngeal defects.

These technical challenges coupled with the success of concurrent chemoradiation therapy protocols in treating SCC of the larynx lead to the wide acceptance of "organ-sparing" approaches in the treatment of oropharyngeal carcinoma. The concurrent use of platinum-based chemotherapy regimens with external beam radiation as definitive therapy for malignancies of the BOT is not without significant morbidity, including long-term gastrostomy tube dependence and osteoradionecrosis of the mandible.

Advances in laser and optical technologies and the development of specialized instrumentation for transoral exposure and access to tumors of the BOT have contributed to a renewed interest in primary surgical treatment for selected malignancies of the BOT. Benefits of transoral surgical resection include earlier return of speech and deglutition, reduced operative morbidity, and pathologic data obtained from histologic analysis of surgical specimens to more precisely select patients for adjuvant treatment protocols. This approach permits deintensification of adjuvant chemotherapy and radiation to employ its use only when necessary, and is associated with a decrease in the development of late toxicity and improved return of function and overall quality of life.

HISTORY

Individuals being considered for transoral laser microsurgery of the BOT should submit to a thorough medical and surgical history including current medications, allergies, and a complete review of systems. Typical chief complaints associated with malignancies of the BOT are otalgia, dysphagia, dysarthria, foreign body sensation, oral or pharyngeal pain, changes in the voice, worsening of snoring or exacerbation of sleep apnea

TABLE 7.1 Malignant Neoplasms Arising in the Base of the Tongue

Salivary Gland	Epithelial	Lymphoreticular	Connective	Endocrine	Neural	Metastases
Acinic cell carcinoma Adenoid cystic carcinoma Carcinoma expleomorphic adenoma Clear cell carcinoma Malignant (epithelial) myoepithelial carcinoma Mucoepidermoid carcinoma (low and high grade)	Basaloid SCC SCC	Extramedullary plasmacytoma Lymphoma (Hodgkin, non-Hodgkin, mantel cell) Lymphosarcoma Malignant thymoma	Alveolar soft-part sarcoma of the head neck Fibrosarcoma Liposarcoma Rhabdomyosarcoma	Papillary thyroid carcinoma	Neuroendocrine carcinoma	Breast carcinoma Clear cell carcinoma metastatic from the kidney Hepatocellular carcinoma Melanoma Prostate adenocarcinoma

syndrome, foul breath (from necrotic tumor), and the asymptomatic mass in the neck. The prolonged use of tobacco and alcohol is thought to be the etiology of SCC of the head and neck. Frequently, the exposure to and abrupt withdrawal of these substances predispose patients to postoperative complications related to exacerbation of underlying ischemic cardiac disease, arrhythmias, chronic obstructive pulmonary disease, and alcohol withdrawal syndromes. Recently, the oncologic role of the human papilloma virus (HPV), which has become a major cause of increased rates of BOT SCC, particularly in younger patients without significant exposure to tobacco and alcohol, has been extensively discussed. Patients' sexual history may give some indication as to their relative risk for HPV exposure.

Other factors that should be included in patients being considered for transoral laser microsurgery (TLM) are a clinical history of obstructive sleep apnea, morbid obesity, restriction of neck extension, trismus, prior head and neck surgery, and/or radiation therapy to the head and neck. These factors can be associated with decreased visualization of the BOT (Table 7.2).

Patients with SCC of the BOT will frequently present with cancer metastatic to Zone II as their sole presenting complaint. This is due to the abundance of submucosal lymphatic channels in the BOT. Local symptoms such as dysphagia and foreign body sensation are more commonly observed with exophytic tumors that ulcerate and interfere with oropharyngeal air movement and the passage of the food bolus in the second phase of swallowing. Dysarthria is observed when tumors of the BOT demonstrate a more endophytic growth pattern replacing the intrinsic tongue musculature and causing fixation of the tongue. Gross fasciculation of the tongue is an ominous finding and is associated with extensive perineural involvement of the hypoglossal nerve. Finally, otalgia in a normal-appearing ear can be a manifestation of referred pain from the sensory divisions of the pharyngeal branches of the ninth and tenth cranial nerves.

A subset of cancer of the BOT is carcinoma metastatic from an unknown primary site, often in those who have already undergone bilateral tonsillectomy. These patients present with metastatic SCC in a cervical node without a readily identified primary tumor. These patients harbor small tumors that are undetected on standard physical examination and that can be missed even on directed biopsies of the BOT during a staging panendoscopy. TLM examination of the BOT with laser lingual tonsillectomy provides a systematic method for safely obtaining satisfactory amounts of tissue to identify a primary site of the cancer in the majority of cases (see Section on page 67 entitled "Panendoscopy and Directed Biopsy").

TABLE 7.2 Factors Associated with Unfavorable Exposure of the Base of the Tongue (T Principle)

- Trismus—reduced mandible–maxilla excursion with inability to place appropriate retractors
- Teeth—visualization obscured by dentition
- Tumor—bulky, friable, and/or hemorrhagic tumor obscuring visualization or a tumor with a depth of infiltration into the tongue base that precluded obtaining a satisfactory deep oncologic margin
- Tori—large obstructive maxillary or mandibular tori
- Tongue—relative macroglossia and redundant tongue tissue that cannot be satisfactorily retracted by blades of operating oropharyngoscope, thus collapsing into the lumen
- Tummy—morbid obesity is frequently associated with a narrow oropharyngeal passage and poor visualization.
- Tonsils (lingual)—lingual tonsillar hypertrophy obscuring view of tumor and making differentiation from tumor challenging

PHYSICAL EXAMINATION

A careful and comprehensive preoperative physical examination, including a complete assessment of comorbidities with appropriate cardiac and pulmonary risk stratification, should be performed on all patients undergoing transoral laser microsurgery. Carefully listening to the patient's voice may give an indication as to the degree of extension of the cancer into the BOT. As expected, patients with a normal voice and few local symptoms tend to have smaller, more superficial tumors. Deeply infiltrative cancers can cause fixation of the tongue and paralysis due to hypoglossal nerve involvement resulting in dysarthria, dysphagia, and fasciculation of the tongue. Occasionally the head and neck surgeon will be surprised as to the degree of local infiltration of the tumor and the relative lack of symptoms.

A complete examination of the head and neck, including fiberoptic nasopharyngoscopy and inspection and palpation of the BOT, is also imperative. Aerosolized and topical anesthesia is often necessary to eliminate a bothersome gag reflex in order to achieve a comfortable examination. SCC can present with the typical ulcerating, erythematous, indurated lesion commonly observed in the oral cavity. However, tumors of the BOT are often very difficult to identify visually and separate from the at times exuberant lymphoid tissue of the region. Neoplasms of the BOT, particular minor salivary gland malignancies, are frequently submucosal. Therefore, the examiner must rely upon an asymmetric appearance or irregularity of the contour of the rounded edge of the BOT. Examination of the BOT with a magnified angled Hopkins telescope can be useful in identifying small lesions.

In addition to examining the BOT to assess the dimensions of the primary tumor, a detailed examination of the epiglottis should be performed. Cancer of the BOT may involve the supraglottis either by superficial extension or by deep infiltration. The former can be identified by careful preoperative examination, and the latter requires imaging for confirmation (see below). Superficial SCCs arising in the BOT can extend into the vallecula and migrate superiorly onto the squamous mucosa of the lingual surface of the epiglottis. An epiglottic sparing mucosal resection can be a satisfactory oncologic alternative in this setting. Conversely, deeply infiltrative tumors can involve the preepiglottic space by direct extension through the median thyroepiglottic ligament. The patient may have the classical "hot potato" voice associated with supraglottic carcinoma, and on physical examination the epiglottis will be erythematous, thickened, and firm.

Detailed examination of the neck is necessary in all patients with malignancies in the head and neck. Submucosal lymphatic channels are particularly redundant in the posterior oropharynx, causing the high incidence of cervical node metastases observed in patients with SCC of the BOT. In our own experience, approximately 85% of patients treated for cancer of the BOT will present with a mass in the neck on initial physical examination. In addition to careful palpation of the neck, office ultrasound can be particularly helpful in patients with a clinically N0 neck. This modality provides a rapid, safe, and highly accurate method to assess regional lymphatics and assist in selecting appropriate targets for fine needle aspiration biopsy.

PREOPERATIVE PLANNING

Imaging Studies

Careful preoperative planning begins with a comprehensive history and physical examination. Imaging studies are then employed to gain additional information on the three-dimensional extension of neoplasms of the BOT, the burden of regional metastases, and the presence of metastatic lesions. Depending on the clinical situation, different imaging studies may be required to obtain the necessary clinical data. Contrast-enhanced magnetic resonance imaging (MRI) is preferred for assessing primary carcinomas of the BOT due to the ability of the MRI to acquire data in a multiplanar fashion with better visualization of subtle soft tissue details. These factors allow for more accurate visualization of local tumor extension into the intrinsic muscles of the tongue, the submucosal extension of the tumor, inferior extension into the preepiglottic space, and lateral extension into the parapharyngeal and carotid spaces.

Although it is possible to anatomically stage the neck with an MRI, imaging cervical metastases is best performed with contrast-enhanced CT scans. Criteria for metastatic cervical nodes based on CT scan include a diameter >10 to 15 mm, central necrosis, round shape, and loss of a clear margin of the node borders and obscured adipose tissue planes indicating extracapsular extension.

A rational, cost-effective approach should be used in evaluating patients for distant metastases. The likelihood of distant metastases can be correlated with the clinical presentation of the local tumor and regional nodes. Patients with early Stage (I and II) disease or clinically and radiographically N0 necks receive a standard AP and lateral chest radiograph. Consistent with NCCN Guidelines, I obtain an 18-FDG positron emission tomography–computed tomography (PET-CT) scan on patients with Stage III or IV disease. All patients with unknown primary carcinomas also receive PET-CT.

Panendoscopy and Directed Biopsy

When possible, I obtain histopathologic material for biopsy at the time of office evaluation. This includes fine needle aspiration (using ultrasound as needed) of suspicious cervical masses and, whenever possible, transoral

biopsies of the tongue base. The use of the 90-degree Hopkins telescope with curved laryngeal cup biopsy forceps and the transnasal esophagoscope with wire cup biopsy forceps passed through the working channel have greatly expanded our abilities to obtain pathologic material in the office.

Direct examination of the tumor and endoscopy of the mucosa of the upper aerodigestive tract under anesthesia remain necessary to (a) obtain definitive histopathologic biopsy material prior to definitive resection, (b) assess for synchronous primary malignancies in the head and neck, (c) determine anatomic constraints for access to the tumor, and (d) evaluate the transoral exposure of the BOT, microscopic visualization of the tumor, and ultimate suitability for transoral laser microsurgery.

INDICATIONS

Patients with biopsy-proven malignant neoplasms of the tongue base should be reviewed at a multidisciplinary head and neck tumor planning conference and ideally have presurgical evaluation by members of the head and neck cancer treatment team. Deeply invasive neoplasms requiring (near) total glossectomy are not ideal candidates for transoral laser microsurgery due to the need for flap reconstruction. In general, indications for TLM resection of the BOT include the following:

Broad superficial SCC of the BOT and vallecula

T1, T2, and some early T3 SCC of the BOT

Minor salivary gland neoplasms of the BOT

Select symptomatic benign neoplasms (obstructing lingual tonsillar hypertrophy or lingual thyroid)

CONTRAINDICATIONS

Contraindications for transoral laser resection of malignancies of the BOT are the same as those for any patient being considered for primary surgical resection of a malignancy of the head and neck such as the presence of distant metastases, classically "inoperable" cervical metastases with fixation of the mass into the carotid artery, skull base, and prevertebral soft tissues, and medical comorbidities that preclude safe general anesthesia.

Specific contraindications to transoral laser resection include inability to satisfactorily expose the primary tumor (see Table 7.2), deep infiltration into the BOT as indicated on sagittal contrast-enhanced MRI and confirmed by bimanual palpation, and extension of the tumor into the neck lateral to the carotid artery. Deep lateral extension can result in uncontrolled hemorrhage and/or salivary contamination of the neck, which should be recognized and repaired during the neck dissection. Dissection of the BOT under high magnification can result in disorientation and loss of perspective leading to unintentional injury of the hypoglossal nerve or lingual artery.

SURGICAL TECHNIQUE

Airway Management

TLM resection of cancer of the BOT is performed under general anesthesia with the patient paralyzed until neck dissection(s) are performed. The two major principles related to the methods of airway management are patient safety and maintaining a panoramic view of the tumor. In patients with T1 or T2 laterally located tumors undergoing unilateral neck dissection, these procedures can be performed with orotracheal intubation using an approved laser-safe endotracheal tube.

While there are no absolute indications for placing a primary tracheostomy in these patients, I have found the following guidelines to be very helpful. A primary tracheostomy tube is placed:

1. When preoperative assessment identifies a tumor that would make orotracheal intubation dangerous (exophytic friable lesion or obstruction of the true vocal folds)
2. In all patients undergoing bilateral neck dissections in the event of venous or lymph edema of the larynx
3. In cases where the resection of the BOT extends into the vallecula requiring partial supraglottic resection, thus reducing the patients' ability to protect their airway
4. In cases at higher risk for secondary hemorrhage such as instances where there is significant hemorrhage at the time of primary resection or large exposed surface area

Description of Technique

Several important factors need to be stressed prior to undertaking a transoral laser resection. First, the surgeon must have significant patience and be prepared to change retractor systems and retractor positioning as often

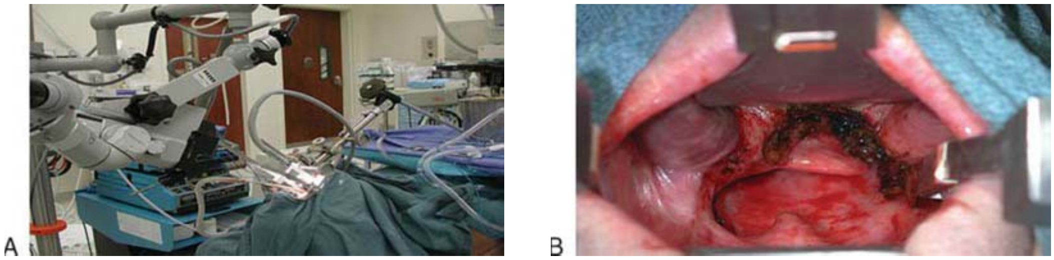

FIGURE 7.1
A: Patient prepared for TLM of carcinoma of the BOT. **B:** TLM defect following resection of squamous cell cancer of the central BOT.

as necessary to insure satisfactory visualization of the operative field throughout the procedure. Second, the tongue has a tendency to anteriorly dislocate from the retractor. A suture placed in the anterior tongue is helpful in establishing and maintaining optimum position of the tongue. Finally, the prominent lymphoid tissue of the BOT and the formation of char and tissue "carbonization" can obscure the differentiation between the tumor and normal BOT. Multiple frozen sections are required during TLM resection of the BOT; therefore, close cooperation with the surgical pathologist doing frozen sections is necessary. In my experience, an average of 6 to 7 frozen sections are required for the typical resection of the BOT.

I initially set the CO_2 laser at 10 W, in a continuous super pulse mode, for dissection. Depending on the size of the tumor, stepwise or "segmental" tumor resection may be necessary (Fig. 7.1). Larger tumors can be divided into several segments with perpendicular laser cuts to facilitate resection without compromising oncologic outcome. Clear communication with the surgical pathologists and operating room staff is necessary to avoid confusion in labeling the specimen. Specimen drawings and diagrams can be useful in this setting (Fig. 7.2). An appropriately sized retractor is placed just anterior to the foramen cecum, the microscope is positioned, and the initial curvilinear incision is made at the level of the circumvallate papillae. If the tumor in centrally located, this anterior incision is carried across the entire tongue base; for more laterally located tumors the incision is terminated at the midline and extends posteriorly. Frozen sections are obtained at this point to confirm that the anterior limits of the surgical resection are oncologically sound.

The plane of dissection is angled to achieve an appropriate deep margin into the BOT. This will require that the surgeon reposition or continually adjust *both* the microscope and the retractor system to maintain appropriate visualization. Caution must be exercised to prevent excessive resection of the BOT, which will result in unintelligible speech, impaired swallowing, aspiration, and inability to control secretions. Specially designed left and right grasping forceps are used to manipulate the surgical specimen as it is developed and to maintain tension between the specimen and the residual tissue to allow for the most efficient cutting with the laser.

Posterior tumor margins can be assessed after properly determining the anterior tumor margins. This requires an incision into the vallecula with the epiglottis retracted inferiorly. Frozen sections of the base of the laryngeal surface of the epiglottis can be obtained at this point. Caution must be maintained with deeper dissection in this region as the surgeon may encounter the hyoid bone medially and the hypoglossal nerve laterally. Frequently bimanual digital palpation is helpful to regularly assess the size and location of the defect and relationships to other structures in the neck.

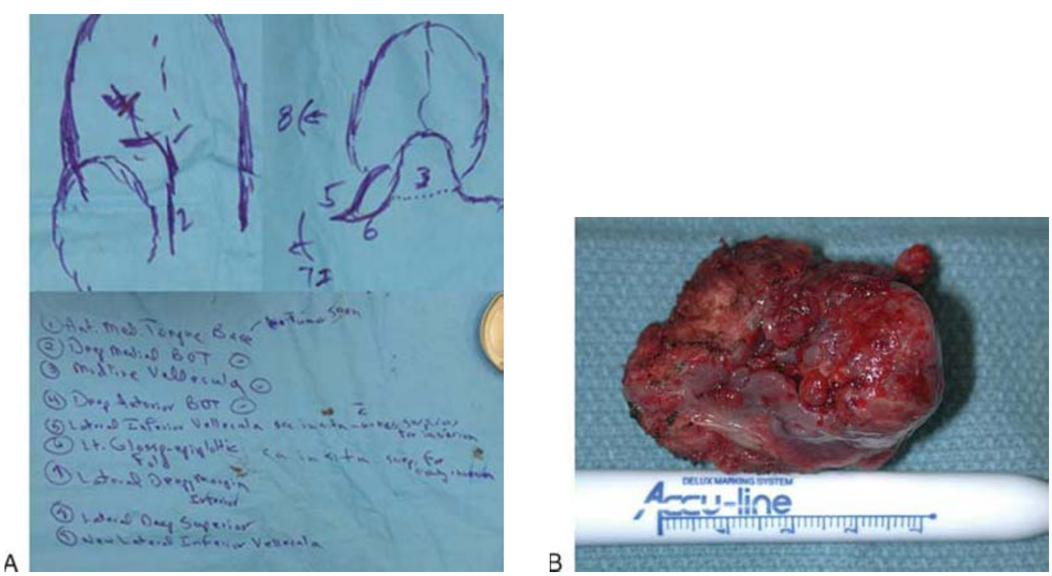

FIGURE 7.2
A: At the time of surgical resection, the specimen and the frozen section margins are labeled and oriented for the pathologists. A diagram of the locations of where the frozen section margins were obtained is often helpful. **B:** Resected T2 SCC of the BOT.

The rich vascularity of the BOT frequently results in troublesome bleeding that reduces visualization. Hemostasis must be continuously achieved as the resection progresses either with a defocused laser or with the suction cautery device. Angled, rigid Hopkins telescopes on a video monitoring system can be placed into the defect both during and at the conclusion of the procedure to inspect it for bleeding and for sites of residual cancer. Topical hemostatic agents can be applied to the defect following complete resection of the cancer with negative frozen sections.

As a general principle, I favor performing neck dissection at the time of the TLM resection of the primary tumor. Advantages of this approach include (1) opportunity to convert to open procedure (lateral or transhyoid pharyngotomy) to complete cancer resection if necessary, (2) selective ligation of the at-risk branches of the external carotid artery to reduce the chance of hemorrhage, (3) ability to meticulously assess the neck for an unrecognized opening into the pharynx and effect repair with strap muscle flaps, and (4) bilateral neck dissections are performed for centrally located or any T3 tumor. I do not perform neck dissections for minor salivary gland tumors of the BOT.

POSTOPERATIVE CARE

Following TLM resection, patients are usually observed overnight in the surgical intensive care unit to monitor airway status and the unlikely event of acute postoperative hemorrhage. Enteral feeding is initiated as early as tolerated through either a gastrostomy or nasogastric tube. Patients begin a mechanical soft diet usually by the second postoperative day, and swallowing rehabilitation is supervised under the direction of speech–language pathologists. Patients receive three perioperative doses of parenteral antibiotics (clindamycin 600 mg IV every 8 hours). Analgesics are continued as needed, and topical chlorhexidine gluconate 0.12% mouth rinses are begun as soon as possible.

Standard wound and suction drain care is used for patients undergoing neck dissection. Patients requiring tracheostomy can usually be decannulated in the standard fashion prior to discharge.

COMPLICATIONS

Complications of TLM can be divided into those caused by retractor placement and those related to the resection. Retractor-related complications are due to excessive extension of retractor blades and prolonged pressure on the tongue resulting in edema and hematoma of the BOT, laceration of the dorsum and lateral tongue, and delayed airway obstruction. Prolonged retractor placement with excessive pressure has also been associated with compression of the lingual nerve between the retractor blade and the inferior border of the mandible resulting in permanent or temporary taste disturbance and anesthesia of the tongue. A similar mechanism has been proposed for compression of the hypoglossal nerve between the retractor blade and the hyoid bone resulting in paralysis of the tongue. Other retractor-related complications include injury to the teeth and lacerations of the lip.

Resection-related complications include injury to the teeth, laser thermal injury, and endotracheal tube fire, hemorrhage, and aspiration of blood, airway obstruction, and delayed recovery of speech and swallowing. Severe life-threatening and potentially fatal hemorrhage following TLM is fortunately rare (<2%). Careful attention to hemostasis by judicious use of the suction cautery, transoral clip hemostasis of identified bleeding vessels, and elective transcervical ligation of at-risk branches of the lingual, facial, and ascending pharyngeal arteries has been advocated. Injury to the teeth can be prevented by carefully placing any one of a number of commercially available plastic tooth protectors. Custom thermoplastic tooth guards can be fabricated from sheaths of Aquaplast external nasal splint. Fortunately, with meticulous attention, surgical site preparation and patient protection laser fires and thermal injuries are rare complications.

Finally, resection of cancers extending laterally on to the pharyngeal wall can result in salivary contamination into the neck with subsequent infection, abscess, or pharyngocutaneous fistula. Some authors advocate delaying neck dissection 1 to 2 weeks after transoral laser resection to avoid this complication. I advocate neck dissection at the time of primary cancer resection with careful inspection of the cervical defect to identify areas of possible breach of the pharyngeal wall and contamination of the neck. Such areas can then be over sewn and bolstered with local tissue such as the strap muscles or the platysma. Carefully placed suction drains and 1 to 2 days without oral intake are then used to facilitate coaptation of the neck flap to the neck wound (Table 7.3).

RESULTS

Increased experience and the sophistication of TLM techniques have resulted in a reexamination of the role of primary surgery in the management of oropharyngeal cancer. By excising the cancer transorally, the surgeon obviates the need for pharyngotomy and can significantly reduce the attendant surgical morbidity without

TABLE 7.3 Complications Mentioned in the Literature Associated with Transoral Laser Microsurgery for Tongue Base Carcinoma

- Aspiration (blood, secretions, and oral alimentation)
- Dysarthria
- Dysphagia
- Hemorrhage
- Intraoperative fire
- Nerve injury (hypoglossal or lingual)
- Taste disturbances

compromising the functional and oncologic results. Single-modality TLM with or without neck dissection has been successfully used in selected previously untreated Stage I, II, and III cancer of the oropharynx with an estimated 5-year local control rates of 90%, 74.3%, and 70% respectively. Increased rates of local recurrence are associated with increasing T stage. Our own experience for SCC of the BOT is similarly favorable. Estimated 5-year survival rates of 80% were observed in my patients with no patient requiring either a permanent tracheostomy or gastrostomy tube and with a majority of patients reporting normal diet and speech. These single-institution results are consistent with a recently published multicenter TLM. In this study, an overall survival rate of 79.4% at 49 months, with 97% local control and 87% of patients with normal swallowing or mild episodic dysphagia were reported.

A significant potential advantage of TLM is the ability to combine it with external beam radiation or chemoradiation in a timely fashion with minimal postsurgical delay. The poor prognosis of HPV-negative SCC of the BOT may warrant multimodality approaches, since CRT has not been successful in improving satisfactory oncologic outcomes. Additionally, TLM-based treatment strategies provide a platform for examining the potential for "deintensifing" adjuvant treatments to further improve or enhance the quality of life in patients with carcinoma of the BOT.

PEARLS

- Prior to surgical management, rigorous evaluation and treatment planning, including imaging studies, are essential. In patients diagnosed with a malignant tumor, PET-CT may provide valuable information that could alter the staging and treatment planning.
- Biopsy prior to TLM is essential in patients with a lesion of the BOT to rule out lymphoreticular or other tumors not treated with primary surgery.
- Staging panendoscopy may be necessary to determine whether or not a particular patient will be a candidate for TLM based on tumor characteristics or anatomic constraints limiting exposure.
- Appropriate instrumentation, particularly a variety of retractor systems, should be available prior to beginning TLM.
- The surgeon should be experienced in open oropharyngeal surgery or have the ability to covert to an open procedure should that be necessary either to control margins or to obtain hemostasis.
- Hemostasis is critical during TLM to maintain visualization of the tumor resection and margins.

PITFALLS

- Attempting to proceed with TLM without detailed preoperative anatomical assessment of the patient
- Using existing instrumentation possibly ill-suited for correct exposure
- Assuming that cancers of the BOT can be excised without repositioning the microscope or changing retractors
- Inadequate use of frozen sections to verify margins
- Failure to realize that TLM of the BOT is technically very challenging and requires an extreme amount of patience

INSTRUMENTS TO HAVE AVAILABLE

- FK retractor system with notched blades.
- Davis blades with integrated suction for Crowe Davis retractor.
- Stem self retaining oropharyngoscope.
- Steiner instrumentation with graspers, clip appliers and suction cautery.

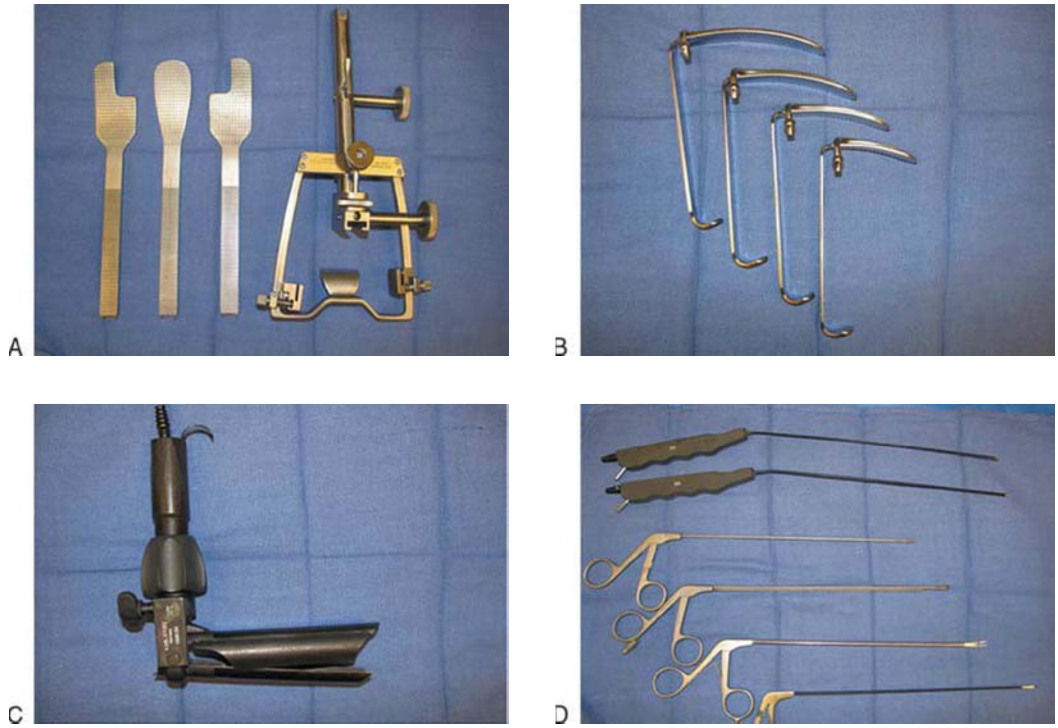

FIGURE 7.3
Instrumentation for TLM; **A:** FK retractor system with notched blades; **B:** Davis blades with integrated suction for Crowe-Davis retractor; **C:** Steiner self-retaining oropharyngoscope with integrated suction; **D:** Steiner instrumentation with graspers, clip appliers, and suction cautery.

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Note: This surgical atlas is required for anyone seriously considering incorporating transoral laser microsurgery into their head and neck practice. It is clearly written, well illustrated and reflects the wealth of experience gained by the true pioneers in the fields of transoral laser surgery for benign and malignant disease.

8 SUPRAHYOID PHARYNGOTOMY

Robert L. Ferris

INTRODUCTION

Suprahyoid pharyngotomy is a safe and efficient approach to excise carefully selected benign and malignant tumors arising in the base of the tongue and the posterior wall of the oropharynx. This technique provides excellent exposure for excision of the tumor while maintaining good function and excellent cosmesis. However, accurate assessment of the tumor in preoperative planning and meticulous attention to detail intraoperatively are the secrets for success, as in most surgical practice.

Traditionally, surgical approaches to these sites include segmental resection of the mandible with partial glossectomy, lateral pharyngotomy, and mandibulotomy. These procedures, however, may produce cosmetic deformities and interfere with deglutition, often resulting in disabling aspiration. In 1895, Jeremitsch became the first surgeon to use the suprahyoid approach. His decision was based on observation of a patient who had attempted suicide. During the attempt, a laceration was produced that approximated a pharyngotomy. Jeremitsch noted that bleeding was minimal, no nerves were severed, and the patient healed favorably.

The suprahyoid approach for T1/T2 squamous cell carcinomas of the base of the tongue has been employed for many years with normal speech, good cosmesis, swallowing without aspiration, and an excellent cure rate. The use of this approach has also been reported in the management of benign and malignant salivary gland tumors of the base of the tongue, excision of lingual thyroid, and the treatment of juvenile angiofibroma of the nasopharynx. This approach is also very efficacious in the management of limited lesions of the posterior pharyngeal wall, and limited lesions of the epiglottis. Tumors of the base of the tongue should be posterior to the circumvallate papillae; otherwise, a functional defect will be created.

HISTORY

A detailed history, clinical examination, and imaging studies are essential and may provide additional insights into the etiology of the lesion. Patients presenting with an oropharyngeal neoplasm have a number of presenting symptoms, such as an asymptomatic mass in the neck, change in speech and swallowing, pain, hemoptysis, otalgia, and trismus. In the past, a majority of the patients who presented with squamous carcinoma had a pertinent history of tobacco and alcohol use. Subsequently, with the emergence of human papilloma virus, many of these patients no longer have the traditional risk factors. The patient should be questioned regarding nutritional status and weight loss.

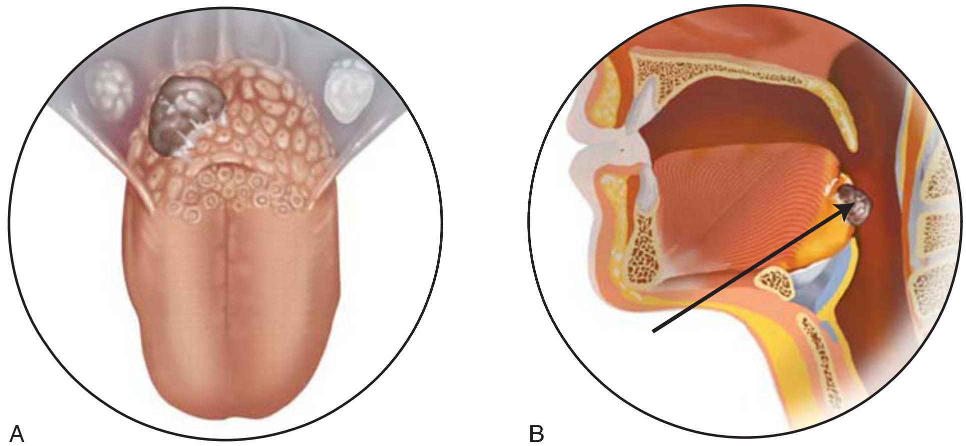

FIGURE 8.1
A: Superior view of the cancer of the right base of the tongue. **B:** Sagittal view of the cancer of the right base of the tongue showing the surgical approach through the suprahyoid space (*arrow*).

PHYSICAL EXAMINATION

A thorough head and neck examination should include a transoral view of the oral cavity and oropharynx. The superior surface of the cancer may be seen in cooperative patients using a tongue blade to depress the base of tongue (BOT) (Fig. 8.1). Fiberoptic endoscopy should also be performed to assess the lateral and inferior extent of the tumor mass, as well as its bulk and involvement of surrounding structures. The neck should be palpated carefully, particularly ipsilateral to the tumor, with a focus on level II, the most common site for lymph node metastasis for cancers of the oropharynx. Clinical staging using physical examination should be corroborated with radiographic imaging to ensure correct patient selection.

INDICATIONS

T1/T2 squamous cell cancer of the base of the tongue as well as other small malignant or benign tumors of the posterior wall of the oro- or hypopharynx may be excised with this technique. Primary closure of the mucosa of the posterior pharyngeal wall to prevertebral fascia or reconstruction with a split-thickness skin or dermal graft can be used for reconstruction of the defect.

CONTRAINDICATIONS

Excision of a cancer larger than T2 is not recommended because to obtain clear margins for a larger tumor, the entire posterior wall, including the muscles of deglutition, will be resected, resulting in dysphagia and aspiration problems. Resection of the base of the tongue anterior to the circumvallate papillae is a relative contraindication to this approach, because the defect would be difficult to close primarily, the anterior margin of resection may be compromised, and dysphagia and aspiration are predictable complications. Involvement of the lateral pharyngeal wall or tonsil may require extension of the approach, such as adding a lateral pharyngotomy to provide adequate exposure.

PREOPERATIVE PLANNING

Correct preoperative staging is essential to determine whether suprahyoid pharyngotomy is the best surgical approach for limited squamous cell carcinoma, adenocarcinoma, benign tumors of the base of the tongue, or tumors including squamous cell carcinoma of the posterior pharyngeal wall. Physical examination, especially palpation, remains the most important aspect of the evaluation. Magnetic resonance imaging (MRI) has proved to be the most sensitive modality for evaluating tumors involving the base of the tongue because it provides excellent soft tissue definition, and fine-cut computed tomography (CT) scanning also provides useful preoperative information (Fig. 8.2). Gross invasion of the preepiglottic space and the depth of infiltration into the base of the tongue may be determined by obtaining sagittal MRI scans of the tongue base–larynx complex. This information is of importance because patients with involvement of the preepiglottic space, with or without involvement of the epiglottis, are not candidates for this technique. The high signal intensity of the preepiglottic adipose tissue usually can be distinguished from the dense fibers of the hyoepiglottic ligament, tongue base musculature, lingual lymphoid tissue, and cancer.

FIGURE 8.2 Contrasted CT scan of the cancer of the base of the tongue. The tumor tissue is visible in the BOT and vallecula, helping to characterize the lateral and deep extent of the excision required, thus guiding the surgical approach.

In the era of nonsurgical treatment as well as transoral robotic and laser surgery for oropharynx cancers, suprahyoid pharyngotomy is used less frequently. In cases of trismus, obesity, lack of exposure, cervical spine difficulties, and neck extension, this approach is preferable to transoral approaches. Direct laryngoscopy and direct evaluation of the lesion of the base of the tongue with palpation of the lesion is the most important way of evaluating the tumor. This also pertains to cancer of the posterior pharyngeal wall. The structures of the oropharynx and hypopharynx play a key role in swallowing. Temporary aspiration is a predictable postoperative occurrence. Accordingly, the patient's functional status, especially as it pertains to pulmonary function, must be considered in patient selection. Patients with severe pulmonary disease may require either laryngotracheal separation or laryngectomy to protect them from life-threatening postoperative aspiration if this technique is extended to resection of T3 to T4 lesions.

SURGICAL TECHNIQUE

General anesthesia is induced, and a tracheostomy is performed as a first step so that the endotracheal tube does not interfere with exposure. When appropriate, the procedure is performed in conjunction with either unilateral or bilateral neck dissection. Intravenous perioperative antibiotics are given to cover oral flora. Before making the skin incision, a direct laryngoscopy may be performed (or repeated) for confirmation of tumor extent and location.

A superiorly based apron flap is outlined if bilateral selective neck dissections are to be performed (Fig. 8.3) or a "hockey stick" incision for unilateral selective neck dissections, and the flap is elevated. The suprahyoid muscles are sharply separated from the hyoid bone. Care must be taken laterally around the greater cornu of the hyoid bone to identify the hypoglossal nerve and lingual artery and to dissect them until they enter the musculature of the tongue. This will help to avoid injury to the hypoglossal nerve and lingual artery.

After the pharyngotomy is made to enter the vallecula (Fig. 8.4A), the dissection is facilitated by grasping the hyoid bone with a tenaculum and pulling it into the wound. Superior retraction of the separated suprahyoid tongue musculature will define the hyoepiglottic ligament extending from the broad hyoid origin to the narrow insertion into the epiglottis. The mucosa of the vallecula is loosely attached to the epiglottic cartilage and is elevated completely off the lingual surface of the epiglottis as far as the tip. An incision through the mucosa just superior to the tip of the epiglottis provides entry into the pharynx. A broad right-angled retractor (such as a Deaver) is inserted above the tongue base, and retraction is exerted on the hyoid bone while the pharyngotomy is completed. A tenaculum is placed on the tongue base, and the tongue base is drawn into the wound (Fig. 8.4B). The hypoglossal nerves and lingual arteries are retracted laterally. After final assessment, the lesion is excised from the tongue base. If there is an extension of cancer to the tonsil fossa, lengthening of the excision can be made to resect the cancer. Moore and Calcaterra reported oncologic success even in T3 squamous cell cancer of the base of the tongue with this approach, together in some cases with a supraglottic laryngectomy. I have tended not to use it for T3 because of considerable problems with delayed deglutition and chronic aspiration.

After the cancer has been removed and adequacy of the resection has been verified by frozen section analysis, a multilayer primary closure of muscle and mucosa is performed with inverted sutures (Fig. 8.5). There has been no need in our series of cases to use either a skin graft or pedicled or free flaps.

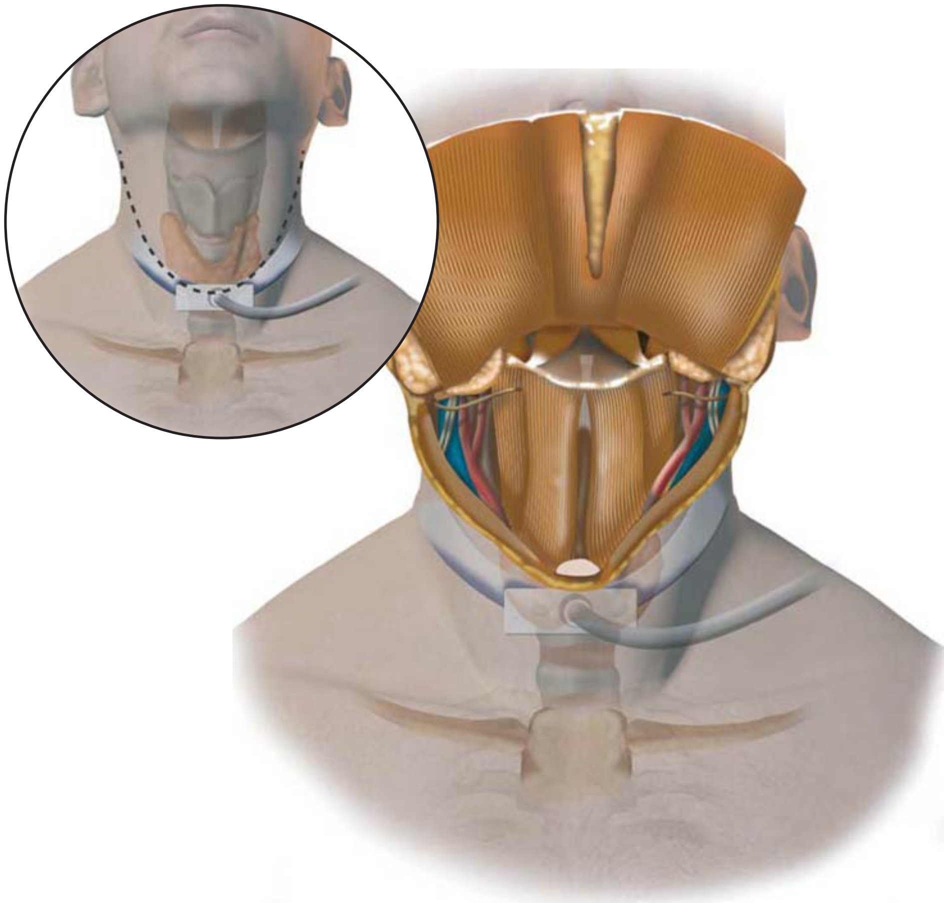

FIGURE 8.3
Elevation of the cervical flap to expose the suprahyoid region. A tracheostomy tube is placed early to eliminate the need for the orotracheal tube. The tracheostomy is placed in the incision for the neck dissection.

The cervical wound is closed over hemovac drains. Special attention must be given to closing the subcutaneous tissues to the strap muscles around the tracheostoma to prevent contamination of the cervical wound when the patient coughs. Safety features for the tracheostomy include placement of traction sutures and sewing the neck plate of the tracheostomy tube to the surrounding skin. Tracheostomy tapes are not used in cases where a large apron flap is used to prevent interference with circulation to the flap.

The technique is modified in patients in whom the pharyngotomy is made to resect lesions of the posterior pharyngeal wall. After the pharyngotomy is made, the tumor is identified and excised from the posterior pharyngeal wall. Frozen section control is performed, and hemostasis is obtained. There are several possibilities for reconstruction of the defect. These include simply sewing the mucosa either to the posterior muscular wall, if it remains after resection, or more commonly, to prevertebral fascia. Alternative methods include use of a skin or dermal graft. The graft is immobilized with a bolus of medicated gauze, which must be removed endoscopically in the operating room under general anesthesia any time after the fifth postoperative day.

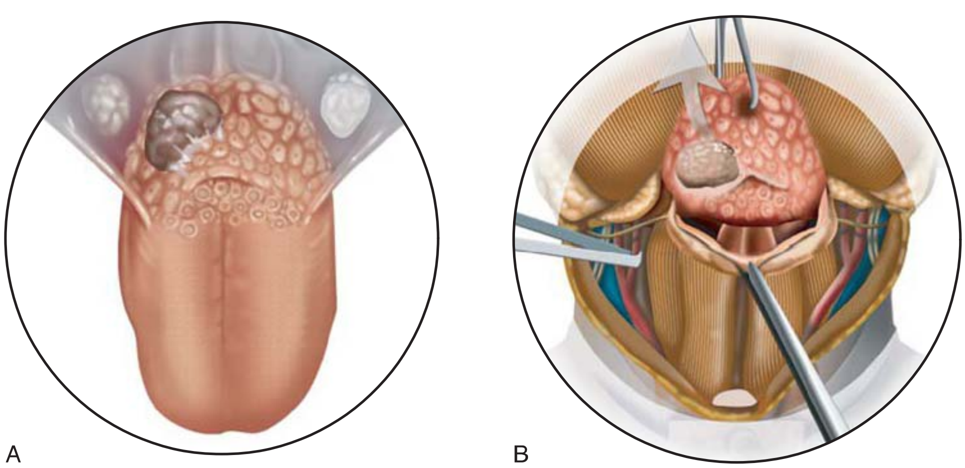

FIGURE 8.4
A: Suprahyoid pharyngotomy is performed, entering the vallecula contralateral to the cancer. **B:** Using a tenaculum, the base of the tongue is brought into the field through the suprahyoid pharyngotomy for direct inspection and resection of the cancer.

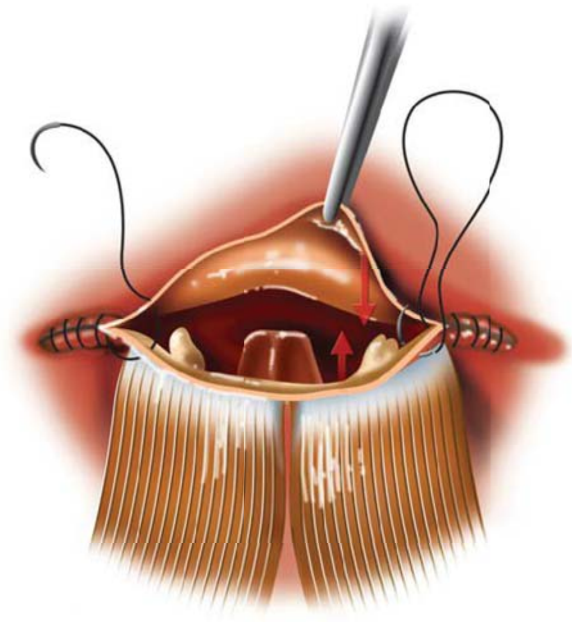

FIGURE 8.5 Inverting sutures are used to close the pharyngotomy in watertight fashion.

Transhyoid pharyngotomy may also be used as a technique for total glossectomy. Patients whose cancer involves the vallecula and in which the tonsil or lateral pharyngeal wall is involved are not candidates for this procedure. The transhyoid pharyngotomy is begun by grasping the hyoid bone and distracting it inferiorly; using the coagulating current, the suprahyoid muscle is released, and the superior aspect and greater cornu of the hyoid bone are skeletonized. The digastric tendon is detached from the hyoid bone and transected. The stylohyoid muscle is transected. The facial artery is identified and ligated to minimize bleeding. The hypoglossal nerve is transected. The dissection is then carried superiorly in the preepiglottic space, wiping the mucoperichondrium off the lingual surface of the epiglottis. When this has been completely mobilized up to the tip of the epiglottis, a pharyngotomy and tumor resection are performed by transecting the mucosa at the junction of the base of the tongue and the vallecula. The periosteum of the lingual surface of the mandible is undermined off the bone up to the dental line of the alveolar ridge. The tongue base is grasped with two Lahey clamps and brought down into the wound. Dissection is then carried anteriorly along the lateral floor of the mouth, which is well seen because of the earlier undermining of the periosteum. The dissection is carried anteriorly and the specimen removed.

In patients with a total glossectomy, a cricopharyngeal myotomy is performed while frozen sections of the specimen are examined. Appropriate reconstruction, usually with a pectoralis major myocutaneous flap or a free tissue transfer, follows this procedure. Some surgeons routinely suspend the larynx, feeling that the more superior position decreases aspiration. It is important to adequately suspend the pectoralis flap to avoid gravity-induced dehiscence of the suture line. This may be facilitated by circumdental sutures or sutures placed through holes drilled in the mandible in edentulous patients.

POSTOPERATIVE MANAGEMENT

Patients should receive routine postoperative care for tracheostomy and to the cervical wound. Perioperative nutrition is achieved by nasogastric tube for approximately 7 to10 days. The tracheostomy cuff is kept inflated for 3 to 5 days to divert respiratory airflow from disrupting the suture line. Resolution of airway edema is monitored by indirect laryngoscopy and ability to breathe around the tracheostomy tube (with the cuff deflated). Decannulation is achieved before removal of the nasogastric tube and the beginning of oral feeding. Initial feedings take place after instructions from the speech pathologist, who teaches swallowing to these patients. During this initial retraining of the swallowing act, the speech pathologist sits with the patient at mealtimes and helps her or him attain the technique(s) necessary for swallowing. There are no special aspects of postoperative management for the pharyngotomy wound. Perioperative antibiotics are used in all patients with major clean-contaminated surgical wounds. Great attention has to be paid to management of the neck dissection to make certain that the drains function properly and to detect the formation of hematoma or seroma, chylous leak, or evidence of salivary drainage in the tubes, which may result from wound separation in the oral cavity. Care of the oral cavity includes the use of half-strength hydrogen peroxide as a mouth rinse three to four times per day, and frequent suctioning of secretions from the oral cavity. Dressings are usually applied to support the wound and to give some compression to the neck flaps. To some extent, postoperative care also very much

depends on the type of reconstruction. Care of the tracheotomy tube and frequent and vigorous suctioning of the tracheobronchial secretions are enormously important in protecting the patient's airway and helping to prevent pneumonia. If there is partial loss of the flap or separation of the intraoral wound with drainage into the neck, every effort must be made to separate the flow of saliva from the oral cavity into the neck in an effort to prevent neck infection, particularly in a radical neck dissection in which desiccation and destruction of the carotid artery system may otherwise ensue, possibly leading to carotid rupture.

COMPLICATIONS

In patients in whom this technique is used for total glossectomy, the most common pitfall is patient selection. The development of recurrent pneumonia and lack of ability to swallow may later necessitate a completion laryngectomy of laryngotracheal separation. Patients who do not learn to swallow may require the maintenance of an indwelling gastrostomy tube to provide adequate nutritional supplement.

Occasionally a small cutaneous fistula may be encountered, which heals within 7 to 10 days. Pneumonia immediately postoperatively should be treated with antibiotics. Patients should be decannulated before discharge. Speech and swallowing rehabilitation is useful in the postoperative period.

RESULTS

This operation can be performed only in a highly selected group of patients. In the setting of appropriate patient selection, good postoperative speech and swallowing are accompanied by high cure rates. However, patients with low potential for retraining, poor motivation, lack of good social support, organic brain syndrome, or mental disorders cannot be included in this group. Patients with significant comorbidity, such as cardiac disease, neurologic disorders, and chronic obstructive pulmonary disease, are not satisfactory subjects for this procedure. Even under the best circumstances, patients may be selected as good candidates but turn out to be poor performers. In some patients, the resulting aspiration may be too severe to permit decannulation.

PEARLS

- Lateral extension of cancer into the tonsil or palate, or both, may be inadequately exposed by this technique.
- Posterior extension into the vallecula may require supraglottic laryngectomy with the previously mentioned complications.
- A major pitfall in this technique is underestimating the size of the tumor, with respect to extension either anterior to the circumvallate papillae or superiorly into the area of the tonsil.
- Extension of the tumor anteriorly may require removal of the oral tongue, which may result in chronic aspiration and difficulty swallowing, requiring laryngectomy, laryngotracheal separation, or placement of gastrostomy tube.

PITFALLS

- Selecting the wrong flap
- Creating a skin paddle too small for the defect
- Positioning the skin paddle too proximal on the muscle so that the pedicle is too short to permit anterior approximation
- Failing to adequately close the wound; this usually is due to errors in suturing sequence so that the completed portion of the closure precludes access to the incomplete portion.
- Failing to reinforce the skin closure with a muscle closure
- Failing to suspend the muscle from the mandible, leading to gravity-induced dehiscence.

INSTRUMENTS TO HAVE AVAILABLE

- Standard head and neck surgical set
- Deaver (GI) retractor for the vallecula
- Rigid laryngoscopy set
- Tonsillectomy set and mouth retractors/tongue blades
- Allis clamp and tenaculum (for hyoid and BOT retraction)
- Headlight for primary surgeon

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9 TRANSCERVICAL PHARYNGOTOMY

Dennis H. Kraus

INTRODUCTION

Most of the tumors in the oropharynx, particularly the base of the tongue, are malignant. The majority are squamous cell carcinoma. The second most common malignant tumors are cancers of salivary gland origin, and rarely, cancers of other histologic subtypes will present in the base of tongue. Table 9.1 lists the lesions from my experience and those reported in the literature. A number of operative approaches and techniques can be employed in removing these tumors. The precise location of the tumor, the experience and expertise of the surgeon, and a host of other factors may impact the choice of the surgical approach. Note that a number of instances in which the technique of transcervical pharyngotomy has been employed in the past may have been supplanted by the use of transoral robotic surgery (TORS). Typically, transoral direct laryngoscopy is performed to allow a complete inspection of the tumor and to render a definitive histologic diagnosis in order to allow for subsequent treatment planning.

The use of this technique must be placed in the context of additional treatment options. For many patients with squamous carcinoma of the oropharynx, there are both primary surgical and nonsurgical treatment options available. Surgical options include the increased use of TORS, or laser excision, as well as mandibulotomy/mandibulectomy approaches for more advanced cancers. Chemoradiation is clearly an option for patients with both early- and advanced-stage cancer. To date, there are no definitive data showing improved survival or quality of life for either modality.

HISTORY

The patients presenting with a tumor of the base of the tongue/oropharynx have a number of presenting symptoms, including an asymptomatic mass in the neck, change in voice and swallowing, pain, hemoptysis, otalgia, and trismus. A detailed history, clinical examination, and imaging studies are essential and may provide additional insights into the etiology of the lesion.

In the past, a majority of the patients who presented with squamous cell carcinoma had a history of heavy tobacco and alcohol use. However, with the emergence of HPV (human papillomavirus), many patients with cancer of the oropharynx no longer have the traditional risk factors. Information regarding sexual activities should be elicited as part of a thorough history as this is thought to be a sexually transmitted disease.

PHYSICAL EXAMINATION

The physical examination of the patient presenting with a tumor of the oropharynx/base of the tongue requires a complete examination of the head and neck. Evaluation of the oral cavity focuses on the presence of trismus as it may impact upon surgical access. An estimation of the mobility of the tongue is essential to exclude

TABLE 9.1 Malignancies Arising from the Base of the Tongue

I. Squamous cell carcinoma
   A. HPV positive
   B. HPV negative
II. Minor salivary gland origin
   A. Acinic cell carcinoma
   B. Adenocarcinoma
   C. Adenoid cystic carcinoma
   D. Carcinoma—Ex pleomorphic adenoma
   E. Mucoepidermoid carcinoma
III. Sarcomas
   A. Alveolar soft part sarcoma
   B. Fibrosarcoma
   C. Liposarcoma
   D. Rhabdomyosarcoma
   E. Additional subtypes
IV. Mucosal melanoma

significant infiltration of the tongue resulting in denervation or atrophy of the hemioral tongue. A combination of transoral mirror and flexible laryngoscopic evaluation of the base of the tongue is essential. This allows for assessment of the extent of the cancer in terms of central, unilateral, or a bilateral involvement of the base of the tongue. Evaluating extension to the adjacent tonsil, lateral pharyngeal wall, posterior pharyngeal wall, supraglottic larynx, or piriform sinus is critical in planning the treatment. In many instances, the tumor extension may be subtle and imaging is complementary. Evaluation of the airway is also critical in terms of anticipating management of the airway in the operating room. Many of these patients may present only with a metastatic lymph node in the neck. Complete assessment of the at-risk cervical lymph nodes is essential for both the purpose of treatment planning and surgical access.

INDICATIONS

- A patient in whom TORS is not feasible due to impaired exposure, body habitus, or trismus
- Extended procedures with resection of the hyoid bone or contiguous soft tissue extension in the neck
- Avoidance of cosmetically unsightly lip-split procedures and avoidance of a nonhealing mandibulotomy site.

CONTRAINDICATIONS

There are a number of surgical approaches to oropharyngeal neoplasms, specifically those arising in the base of the tongue. This includes mandibulectomy, mandibulotomy, the aforementioned transcervical pharyngotomy approach, and lastly TORS. To use a TORS approach, there must be adequate access, and trismus would be considered a significant contraindication. For the rare patients with invasion of the mandible, segmental resection of the mandible is necessary and a transcervical pharyngotomy would not be appropriate. Mandibulotomy provides outstanding access but is associated with the cosmetic deformity of a lip-split incision and the potential for a nonhealing osteotomy site.

For the patients being considered for a transcervical pharyngotomy, previous neck dissection is a relative contraindication. The ability to manage the carotid artery and potential preservation of the ipsilateral hypoglossal nerve may be hindered by a previous neck dissection or anatomy distorted by extensive scarring.

Extended procedures that require resection of the inferior aspect of the lateral or posterior pharyngeal wall can all be performed when appropriate planning has been considered. Even extended procedures such as laryngectomy can be performed via a transpharyngeal approach.

PREOPERATIVE PLANNING

Imaging Studies

Imaging plays a critical role in the evaluation of the patient with a mass in the oropharynx. Both computed tomography (CT) and magnetic resonance imaging (MRI) are used in the evaluation of oropharyngeal neoplasms. A CT scan with contrast provides considerable insight into the extent of the primary lesion, as well as the presence of metastasis to the cervical lymph nodes. For more advanced cancers, one can determine the

extent of invasion into the intrinsic musculature of the tongue. In extensive lesions, encroachment onto or invasion of the mandible may also be evident. MRI provides slightly improved determination of the soft tissue interface between the tumor and the adjacent surrounding structures. In advanced cancer extending into the neck, it may provide valuable information in determining the relationship between the cancer and the blood vessels in the neck, specifically the internal carotid artery. MRI is equally adept at identifying lymph node metastasis.

Recently, the positron emission tomography–computed tomography (PET-CT) scan has been useful in defining the location of the cancer. This modality may provide a slightly decreased definition of the extent of the primary cancer, but it is highly adept at identifying metastasis to the cervical lymph nodes. In patients with advanced metastasis to the neck, it is often successful in identifying the small proportion of the patients with distant metastasis, most commonly to the lung and mediastinum.

Preoperative Biopsy

Biopsy of the tumor is performed via direct laryngoscopy in the operating room. Examining the patient under anesthesia allows for palpation of the tumor and is a valuable adjunct in determining its extent. A combination of direct laryngoscopy with the use of the laryngeal telescopes is employed in determining the extent of the tumor.

For deeply invasive cancer within the substance of the tongue, in which efforts at transoral biopsy had been unsuccessful, CT or ultrasound-guided needle biopsy in the radiology suite may provide a diagnosis. It is the rare tumor in which no pathologic diagnosis can be obtained prior to surgery.

SURGICAL TECHNIQUE

The patient is placed under general endotracheal anesthesia via a nasotracheal intubation. The patient is prepped and draped in a standard sterile fashion with access to the oral cavity for the second portion of the procedure. The patient undergoes appropriate cardiopulmonary monitoring, and a Foley catheter (to monitor fluid dynamics) and a rectal thermometer are inserted. The eyes are prepared with placement of ointment, and a nonadhesive tape is used to protect the eyes. I do not typically employ nerve monitoring for this procedure.

An incision is designed from the ipsilateral mastoid tip continuing two fingerbreadths below the angle of the mandible across the midline over the thyrohyoid membrane (Fig. 9.1). If bilateral access is necessary, then a mirror image incision is used to the contralateral mastoid tip. Incision is performed, and subplatysmal flaps are elevated superiorly and inferiorly. The neck dissection, both for N0 and N+ neck disease, includes incorporation of all at-risk and involved cervical lymph nodes with preservation of the uninvolved sternocleidomastoid muscle, spinal accessory nerve, and internal jugular vein. This allows for incorporation of levels I through V.

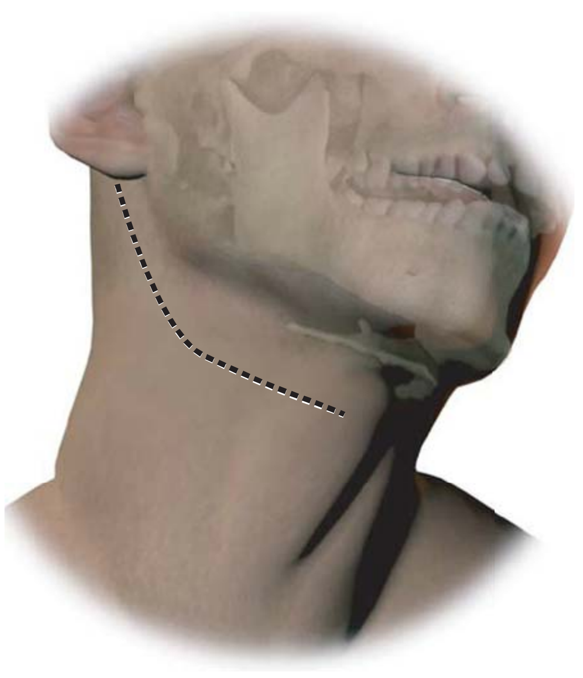

FIGURE 9.1 Cervical incision for transcervical pharyngotomy and modified neck dissection.

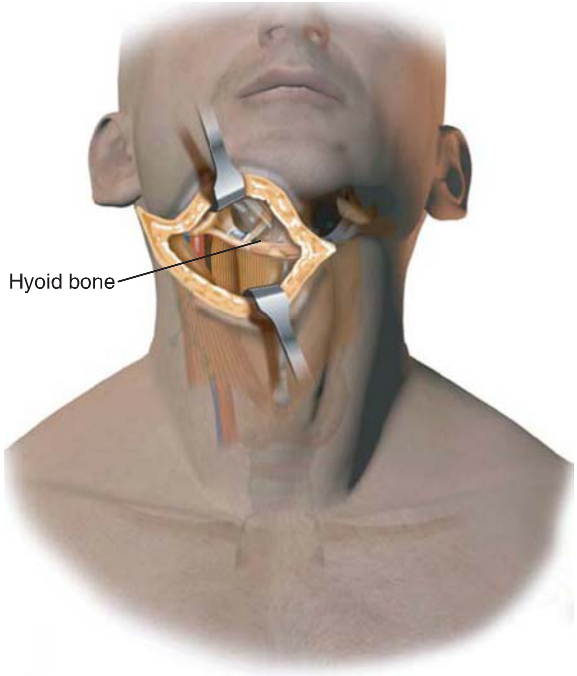

FIGURE 9.2
Completion of modified neck dissection with isolation of the hyoid bone and the hypoglossal nerve.

It is important to resect the submandibular gland in order to have complete access to the superior aspect of the central compartment.

It is essential to isolate the hyoid bone in approaching a unilateral cancer (Fig. 9.2). It is important to ligate both the common facial artery as well as the lingual artery where it arises between the anterior and posterior belly of the digastric. It is often feasible to identify the hypoglossal nerve and dissect it from its origin at the hypoglossal canal at the base of the skull into its insertion into the oral tongue (Figs. 9.3 to 9.7). By performing this maneuver, it is possible to mobilize the hypoglossal nerve free of the anticipated site of resection of the base of tongue and yet maintain the innervation to the anterior two-thirds of the tongue. Care must be taken in mobilizing the hypoglossal nerve as a number of small pharyngeal veins often bridge the nerve and when divided can retract and cause excessive bleeding.

The patient is now placed under paralytic anesthesia. For most surgeons, it is possible to palpate the lateral pharyngeal wall and valleculae in order to determine the optimal access. In part, this is predicated on the preoperative endoscopy. For cancers encroaching upon the vallecula, it is feasible to incorporate a portion of the hyoid bone in the specimen, and a bone-cutting instrument is used to divide the hyoid bone in the midline (Fig. 9.8). Using digital palpation, or a Yankauer suction, back pressure is placed through the pharynx, and

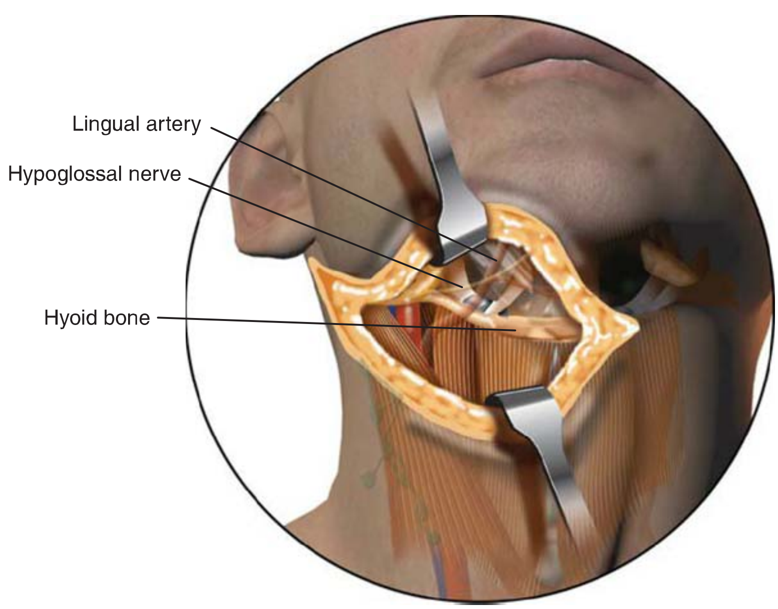

FIGURE 9.3
Skeletonization of the hyoid bone, hypoglossal nerve, and lingual artery.

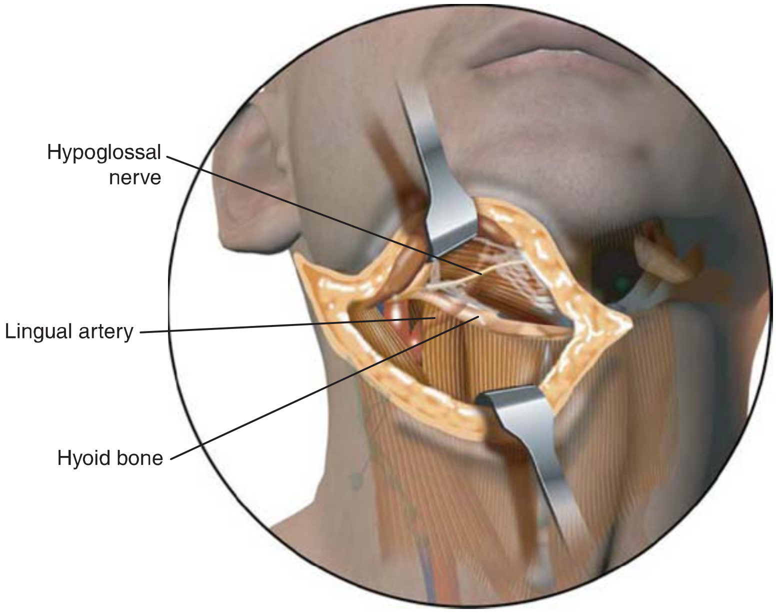

FIGURE 9.4
Course of the lingual artery running deep to the hyoid bone and hypoglossal nerve.

the pharynx is entered in a blind but directed fashion in order to avoid cutting through cancer. A headlight or endoscope is used to provide illumination. Under direct vision, soft tissue dissection is performed incorporating approximately a 1-cm margin around the cancer including the base of the tongue, lateral pharyngeal wall, and any adjacent involved structures. As noted previously, extended operations can be performed via this access including laryngectomy or extended pharyngectomy. Care must be taken in providing meticulous hemostasis, as dissection is performed through the substance of the tongue with its rich arterial blood supply. As noted earlier, the hypoglossal nerve has been elevated free of the underlying base of tongue, maintaining its innervation into the preserved oral tongue. I use a "jump rope" technique in manipulating the nerve superiorly and inferiorly to gain adequate visualization with limited trauma to the nerve. Upon monobloc delivery of the tumor, the specimen is oriented in the frozen section pathology suite by the operating surgeon and it undergoes frozen section margin assessment to assure microscopically negative tumor margins (Fig. 9.9). The pharyngotomy is closed with a 3-0 Vicryl suture on a urologic needle (Fig. 9.10).

Hemostasis is obtained with bipolar cautery. Multiple Valsalva maneuvers are done to assure that hemostasis is complete and that there is no evidence of a chyle leak. A Hemovac drain is placed via a separate stab incision and held in place with a 2-0 silk suture tie in a purse-string fashion.

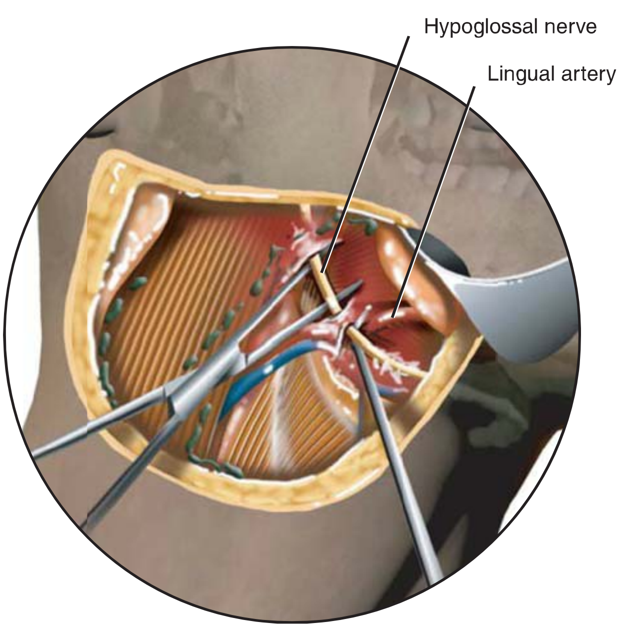

FIGURE 9.5 Dissection and elevation of hypoglossal nerve for the purpose of performing the "jump rope" technique.

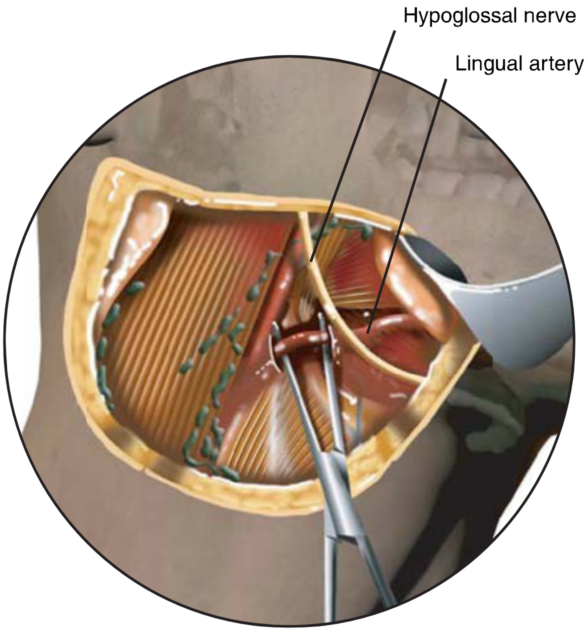

FIGURE 9.6
Isolation of the lingual artery for the purpose of ligation.

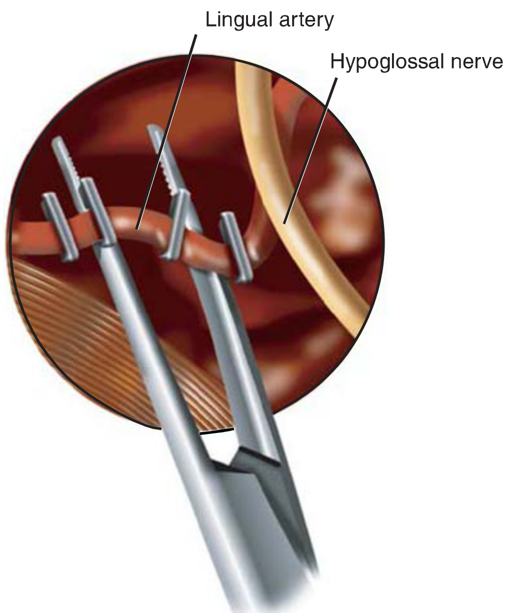

FIGURE 9.7
Ligation of the lingual artery with preservation and elevation of the hypoglossal nerve.

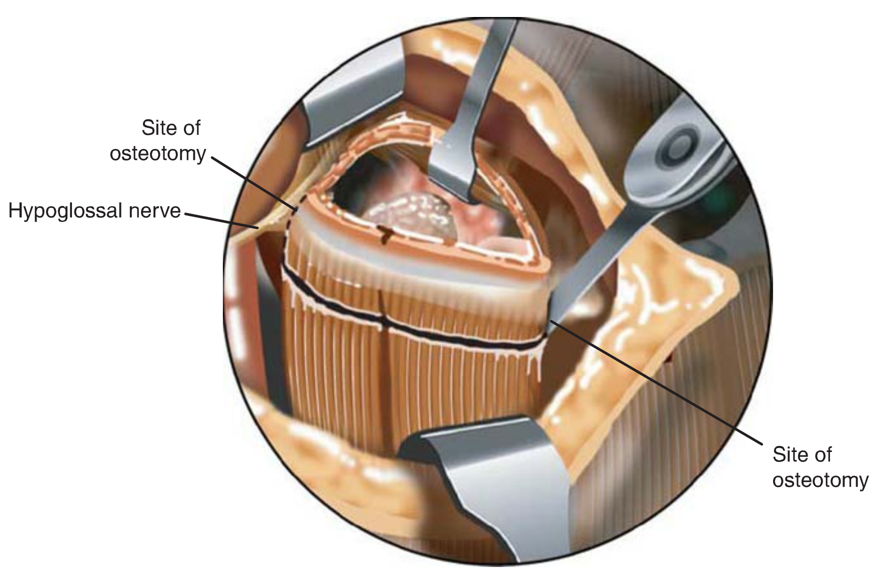

FIGURE 9.8
Osteotomies of the hyoid bone to allow for connection of soft tissue cuts superiorly and inferiorly with tumor isolated upon the base of tongue.

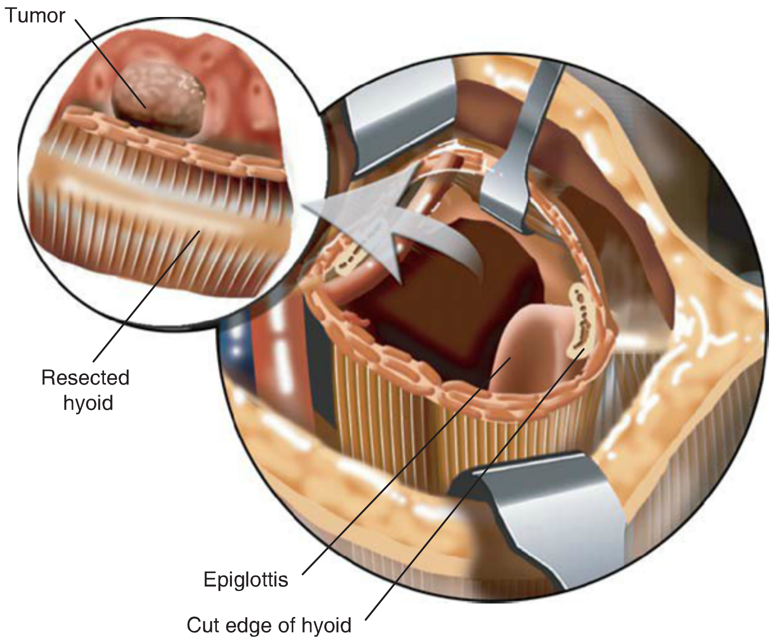

FIGURE 9.9 Transected hyoid bone with base of tongue and infrahyoid soft tissue with preservation of the epiglottis and the hypoglossal nerve.

The wound is closed in multiple layers with interrupted 3-0 chromic sutures and a running subcuticular 4-0 Monocryl suture. Steri-Strips are applied to the wound. Antibiotics are continued for approximately 48 hours postoperatively as extended antibiotic use has not been shown to be associated with a reduced rate of infection.

POSTOPERATIVE CARE

The Hemovac is placed to self-suction. It is typically removed on the 3rd or 4th postoperative day when drainage has decreased below 30 mL for 24 hours. The tracheostomy is downsized to a small uncuffed tube. The patient is evaluated by the speech and swallowing service for adequacy of oral intake on the postoperative days 5 to 7, and assuming normal postoperative swallowing, the tracheostomy and feeding tubes are removed.

COMPLICATIONS

Complications of the surgical procedure are listed in Table 9.2. The incidence of hematoma is relatively low, at approximately 1%. The incidence of wound infection is also relatively low, at approximately 5%. The incidence

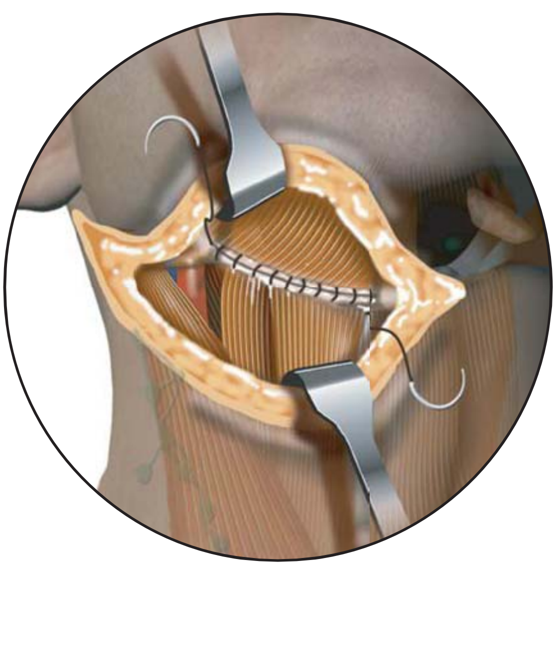

FIGURE 9.10 Layered closure of the pharyngotomy.

TABLE 9.2 Complications Associated with Transcervical Lateral Pharyngotomy

- Chronic dysphagia
- Chyle leak
- Cranial neuropathies
- Fistula formation
- Hematoma
- Wound infection

of fistula formation in nonirradiated patients is extremely low. Should a fistula develop, the wound will be opened, and frequent irrigation and packing will help in the healing process. The incidence of a formation of a fistula is higher in previously radiated patients, approximately 20%. Rarely, the patients will require a secondary procedure for flap closure of the wound. Injury to the cranial nerves is relatively low and is usually related to the neck dissection. Injuries to the marginal mandibular nerve, spinal accessory nerve, vagus nerve, brachial plexus, and phrenic nerve are all relatively rare. Long-term dysphagia is a potential sequel of this surgical procedure. This is usually dependent on the extent of resection rather than the actual surgical procedure. Preservation of the ipsilateral hypoglossal nerve reduces the risk of chronic dysphagia. It is rare that the patients require a long-term or lifelong feeding tube.

RESULTS

Tumors arising in the base of the tongue represent an array of pathologies and are associated with both favorable and unfavorable outcomes. The final pathologic diagnosis determines whether the patient requires adjuvant therapy in the form of radiation with or without chemotherapy. Adjuvant therapy may be associated with impaired speech and swallowing function and may affect long-term quality of life. In addition to the risk of local-regional recurrence, the patients must be monitored for the development of the distant metastasis. This is particularly prevalent in the rare adenoid cystic carcinoma of the base of tongue as it tends to spread via the hematogenous route to the lungs. In the patients in whom no adjuvant therapy is required, long-term functional outcomes are typically favorable.

The major advantage of using the "jump rope" technique is the preservation of the hypoglossal nerve. The patient should be instructed in the use of tongue mobility exercises. Initially, there may be atrophy or denervation of the ipsilateral tongue. However, over 6 months to a year, the oral tongue often returns to a normal and symmetrical appearance with continued improvement in speech and swallowing function. In the patients with chronic disability, speech and swallowing therapy consultation continues.

PEARLS

- Rigorous evaluation and treatment planning—including imaging studies—are essential prior to surgery.
- Cross-sectional imaging consisting of CT or MRI and/or PET-CT may provide valuable information for staging and treatment planning.
- Preoperative evaluation and counseling of the patient are critical.
- Meticulous surgical technique is fundamental to good results.
- Preservation of the ipsilateral hypoglossal nerve allows for improved long-term function.
- Clear margins of resection are dependent upon adequate visualization of the cancer.
- Dissection and preservation of the contralateral lingual artery and hypoglossal nerve complex may be required in extended contralateral procedures.
- Multilayered wound closure of the pharyngeal/base-of-tongue defect is essential in preventing a fistula.

PITFALLS

- Incomplete resection or inadequate margins may be a result of inadequate assessment of the primary cancer.
- Inadequate resection may be the result of inadequate access to the cancer.
- Long-term dysphagia and hemitongue atrophy may be the result of inadvertent trauma to the preserved hypoglossal nerve.

INSTRUMENTS TO HAVE AVAILABLE

- Soft tissue dissection tray
- Head light or endoscope

- Nerve hook
- Bone cutting instrument
- Surgical clips or silk sutures
- 3-0 Vicryl suture curved U urologic needle
- Closed-suction drain
- Tracheostomy tube
- Dobhoff feeding tube

SUGGESTED READING

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10 ROBOTIC-ASSISTED SURGERY OF THE BASE OF THE TONGUE

Eric M. Genden

INTRODUCTION

Cancer of the base of the tongue can be managed surgically or nonsurgically. The decision regarding treatment depends on a variety of factors including the pathology and the stage of the cancer. Other factors such as the location of the cancer, patient considerations, and the surgeon's bias also play a role in the treatment approach. Nonsurgical treatment of cancer of the base of the tongue typically consists of concomitant systemic chemotherapy and external beam radiotherapy.

Surgical approaches include open and endoscopic or endoscopic-assisted surgery. Until recently, transoral laser microsurgery was the only available endoscopic approach. Transoral robotic surgery (TORS) was recently introduced and has quickly gained popularity in the management of both squamous and nonsquamous cell cancer of the base of the tongue. Several studies have demonstrated the feasibility of TORS of the base of the tongue and suggested that primary surgery may confer an advantage by providing essential histologic information that can be used to determine the need for treatment escalation for aggressive cancers or treatment de-escalation for less aggressive cancers. Although randomized controlled trials evaluating these concepts are lacking, our experience and the experience of others strongly suggest that surgery may provide an advantage over combined chemoradiotherapy.

Choosing the appropriate patient for this procedure is arguably as challenging as the technical aspects of the surgery itself. The history, physical examination, and imaging are essential aspects of the preoperative evaluation. This evaluation will determine whether a patient is a suitable candidate for TORS of the base of the tongue.

HISTORY

The history and physical examination are helpful in determining whether a patient is a candidate for TORS. The history may reveal symptoms ranging from odynophagia to otalgia, dysphagia, or frank aspiration. Although referred pain is common, perineural invasion with retrograde extension should be considered because it may limit the surgeon's ability to achieve a tumor-free margin of resection. Similarly, extensive dysphagia or frank aspiration may suggest deep invasion of the base of the tongue, invasion of the hypoglossal nerve, or invasion across the midline. In each instance, surgical resection may result in significant functional deficits so that nonsurgical therapy may be more appropriate.

PHYSICAL EXAMINATION

The physical examination should include palpation of the neck, nasopharyngoscopy, and bimanual palpation of the base of the tongue. Although the nasopharyngoscopy may suggest a well-lateralized tumor, digital palpation may reveal unsuspected invasion of the deep musculature. Submucosal extension that is identified on palpation

may impact the treatment approach and extent of resection. In addition to the information gleaned from the history and physical examination, axial imaging (CT, MRI, or PET/CT) can also provide important information that may not be appreciated by physical examination alone.

INDICATIONS

Because nonsurgical therapy is an option for squamous cell cancer of the base of the tongue, candidates for surgery should be selected based on our ability to achieve a surgical resection with cancer-free margins without leaving the patient with major functional disability. In those cases where a complete resection can be achieved, adjuvant therapy may not be necessary or may be de-escalated resulting in an improvement in function and quality of life.

CONTRAINDICATIONS

The relative contraindications of TORS for resection of the base of the tongue include tumors that exhibit extensive lateral extension, extension across the midline, or deep invasion of the base of the tongue (Table 10.1). TORS for resection of the base of the tongue in cases with extension across the midline may result in irreparable functional disability, and therefore, these patients may be considered for nonsurgical therapy.

Additional considerations include the extent of metastasis to the neck. In those patients with extensive extracapsular spread (ECS), surgical therapy may not obviate the need for systemic chemotherapy. While the implications of ECS in the patient with human papillomavirus (HPV) associated disease is heavily debated, ECS portends a poor prognosis in patients with HPV-negative disease. As such, chemoradiotherapy is typically indicated and surgical management may not benefit the patient.

PREOPERATIVE PLANNING

Imaging Studies

Imaging is an important adjunct to the physical examination and is critical in determining whether a patient is a candidate for TORS of the base of the tongue. The PET/CT provides important information related to the presence of regional and distant metastasis, and the CT may provide information regarding invasion of the hyoid bone. The MRI can serve as an important adjunct to CT. An MRI is often more sensitive for evaluating deep soft tissue extension. The superior nature of the MRI to discern invasion into the soft tissue, perineural invasion, and diffuse poorly marginated cancer of the tongue is important in determining whether TORS is appropriate. The combination of the physical examination and the imaging is an important step in evaluating a patient for TORS.

SURGICAL TECHNIQUE

Because lymphatic drainage of the base of the tongue is bilateral, both sides of the neck should be treated. The notable exception is the patient with a well-lateralized early-stage cancer without evidence of metastasis to the neck. Some would suggest that this patient can appropriately be treated with unilateral management of the neck. The options for treatment include neck dissection or external beam irradiation. I perform the transoral robotic resection followed by the neck dissection as a single operative procedure. Some advocate staging the transoral resection and the neck dissection; however, I have not found this approach necessary.

Before the resection is started, I place a finger into the oropharynx and palpate the tumor and mark the peripheral margins. Because there is no tactile feedback with the robot, the markings are helpful in providing guidance during the resection.

The procedure is begun by determining the most appropriate method for airway management. The options include oral intubation, nasotracheal intubation, or tracheostomy. All three approaches have been

TABLE 10.1 The Relative Contraindications of TORS for Resection of the Base of the Tongue

- Cancers exhibiting extension into the soft tissue of the neck
- Cancers extending across the midline
- Cancers invading the hyoid bone

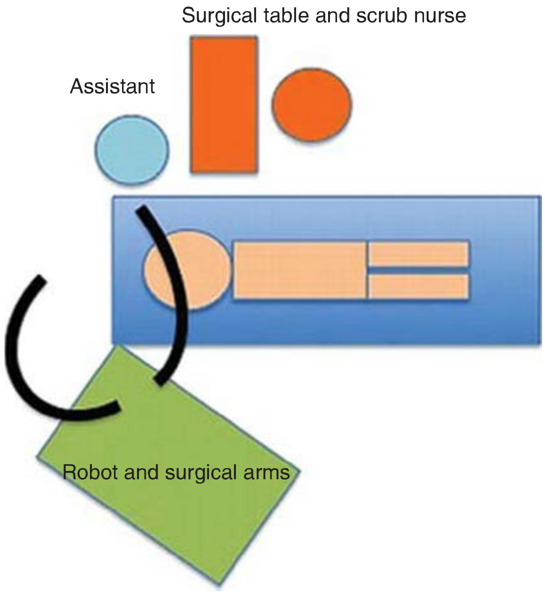

FIGURE 10.1 Figure one demonstrates the robotic setup for a robotic base of tongue resection. Surgical assistant is seated adjacent to the patient's head. The scrub nurse and surgical table adjacent to the patient's torso opposite the robot. The robot is angled at 30 degrees to the patient's bed. This positioning allows the surgical arms to appropriately rotate into a favorable surgical position.

described, and each option offers advantages and disadvantages. For cancers of the base of the tongue, I favor nasotracheal intubation for T1 and small T2 cancers, but for larger cancers, I perform a tracheostomy with the intention of decannulating the patient 1 to 2 days postoperatively. If there is any concern related to the patient's airway, I strongly consider performing a tracheostomy. Following intubation, the patient is positioned 180 degrees from anesthesia, and the room is set up as demonstrated (Fig. 10.1).

Access to the base of the tongue and complete visualization of the cancer is critical to achieve a successful operation. The Crowe-Davis, Dingman, and Fay-Kastenbauer (FK) retractors are the retraction systems used most commonly. The optimal retractor is predicated on the location of the cancer and the anatomy of the patient. Often, each retractor is sequentially placed to determine the optimal retractor for the individual patient. Anatomic factors such as the patient's intraincisal distance, the presence or absence of dentition, and the architecture of the mandibular arch will impact the access to the base of the tongue. I find that FK retractor often provides the best exposure to the base of the tongue; however, the exposure can be improved by placing a single silk suture through the midportion of the tongue and using this suture to pull the tongue anteriorly.

Once the retractor is positioned, I prefer a 30-degree endoscope to improve visualization of the cancer. The robotic arms are placed and oriented according to the position of the cancer; if the cancer is located on the patient's left side, the cutting instrument is placed in the left robotic arm and the retractor is placed in the right robotic arm. This orientation allows for retraction of the cancer and surrounding tissue during the resection. The spatula cautery or robotic laser can be used as the cutting instrument. I prefer the laser because it provides precise incisions with minimal burn artifact. This makes assessment of the margins more accurate.

The resection is started by making the anterior incisions and extending the incision along the medial margin. The cancer transposed laterally as deep incisions into the muscle are performed from medial to lateral. This approach provides control and excellent visualization of the tumor during the resection. After the anterior and medial incisions are complete, the lateral incision is made along the glossopharyngeal sulcus. The high-powered magnification provides an excellent view of the incisions. Normal tongue muscle can be discerned from tumor-bearing tissue by the consistency and dense char that occurs when incising tumor-bearing tissue. In contrast, muscle cuts cleanly with minimal char or burn artifact. During the procedure, it is not uncommon to change instrumentation positions to main control and visualization. Once the resection is complete, the specimen is carefully marked with colored ink to assist with assessment of the margins (Video 10.1). In the case that the cancer extends to the hyoid bone, a transcervical resection of the hyoid can be performed during the neck dissection (Fig. 10.2). I use a sternocleidomastoid flap to reinforce the closure (Fig. 10.3).

Following the primary resection, the robotic instrumentation is removed and the patient is reprepped and redraped for the neck dissection. The selective neck dissection is performed using the standard technique; however, if there is concern regarding the possibility of an orocutaneous fistula, a superior-based sternocleidomastoid flap is elevated and rotated into the operative site to bolster the area and help prevent a fistula. I place a suction drain into the neck and close the incision in a standard fashion.

POSTOPERATIVE CARE

Postoperatively, patients may remain intubated if I am concerned about edema of the airway. If I am concerned about the patient's ability to protect the airway, I perform a tracheostomy. All patients are monitored in an

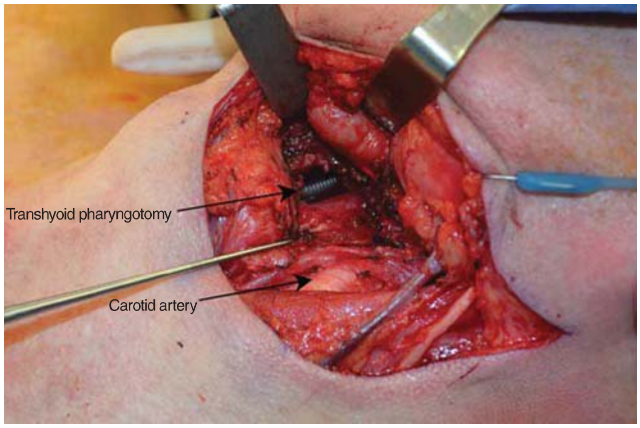

FIGURE 10.2
When a cancer of the base of the tongue extends to the hyoid bone, a transcervical pharyngotomy can be used to achieve a complete resection.

intensive care step-down unit for 24 hours. Because bleeding and airway obstruction represent the most significant acute complications, careful observation during the immediate postoperative period is mandatory.

COMPLICATIONS

Intraoperative complications are sometimes unavoidable, and being prepared and anticipating the potential for complications is important. On the operating room table side, I have tonsil sponges, vascular clip appliers, suction cautery, and an open neck tray in the event that immediate open neck access or an emergent tracheostomy is necessary. The tonsil sponge provides an excellent tool to tamponade bleeding until definitive control can be applied.

Complications of TORS of the base of the tongue include hemorrhage, airway obstruction, and postoperative aspiration. Hemorrhage may occur intraoperatively or postoperatively. Intraoperatively, bleeding can occur as the resection progresses laterally. The lingual artery and several of its smaller branches are at risk as the resection progresses laterally along the glossopharyngeal sulcus. If the vessels are identified, they can be clipped. If the lingual artery is inadvertently transected, the vessel can be controlled by applying pressure with the robotic Maryland grasper while a vascular clip is loaded and applied. Airway obstruction may result from edema immediately following surgery or several hours after surgery. Extensive resections may cause a disruption in venous and lymphatic drainage. This, in turn, can lead to marked edema of the tongue and airway obstruction. I have a low threshold for performing a tracheostomy to prevent a potentially catastrophic airway obstruction, and in borderline cases, I will extubate the patient in a delayed fashion 10 to 12 hours after the procedure when the patient is awake, alert, and able to protect the airway.

RESULTS

Our published results using TORS for the management of oropharyngeal cancer include a combination of cancer of the tonsil and of the base of the tongue, and the results for both groups have been excellent. The majority of patients have been HPV positive, but early results applying this technique to HPV-negative patients has been promising.

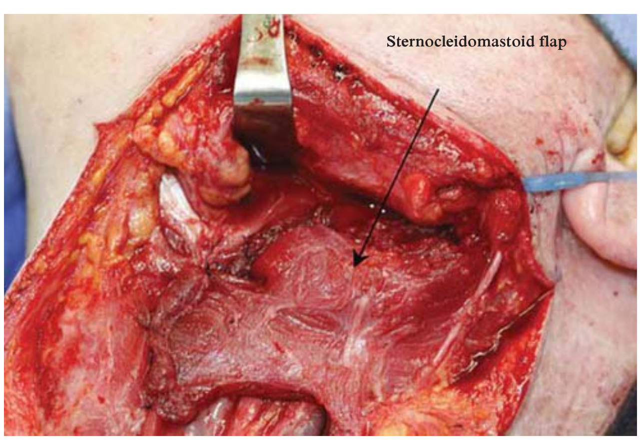

FIGURE 10.3
The sternocleidomastoid flap can be used to bolster the primary closure.

In our series, the use of TORS with neck dissection enables us to evaluate for poor prognostic risk factors such as perineural invasion, lymphovascular invasion, and extracapsular spread. This information allows for the personalization of therapy and has demonstrated excellent oncologic results with preservation of function and quality of life.

PEARLS

- Use a combination of history, physical examination, and imaging to determine if a patient is a candidate for TORS.
- TORS should be applied to those patients who will benefit from the intervention.
- Patients with a cancer demonstrating extensive lateral invasion or extension across the midline may benefit from nonsurgical therapy to avoid extensive functional morbidity.
- Nasotracheal intubation is often ideal to provide unobstructed access to the base of the tongue; however, when operating on larger cancers, a tracheostomy is safer and affords excellent access to the surgical site.
- A traction suture in the tongue will help to pull the tongue anteriorly and improve access to the surgical site.
- When performing the resection, starting anterior and medial provides a controlled approach to the tumor resection.
- In cases where the cancer unexpectedly invades the hyoid bone or the extra oropharyngeal structures, be prepared to perform an open transcervical approach to compete the resection with cancer free margins.
- After the resection is complete, apply positive pressure ventilation to identify any bleeding that may require cauterization.
- Postoperative preparation is essential. Tonsil sponges, vascular clips, and an open neck tray are placed at the bedside.

PITFALLS

- If the retractor does not provide appropriate access to the cancer of the base of the tongue, an alternative to TORS should be considered.
- Lateral dissection may lead to transection of the lingual artery. Preparation to manage this event is essential.
- Airway safety is paramount. Avoidance of tracheostomy may result in airway problems for large or flap-reconstructed cancers or when bleeding is catastrophic.

INSTRUMENTS TO HAVE AVAILABLE

- da Vinci robot system
- Robotic system cautery robotic arm
- Standard head and neck surgical tray

SUGGESTED READING

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11 INTERSTITIAL PHOTODYNAMIC THERAPY OF HEAD AND NECK TUMORS

I. Bing Tan

INTRODUCTION

Photodynamic therapy (PDT) is a technique that uses a combination of a systemic photosensitizing agent with selective activation of the agent at the tumor location by delivering a certain wavelength of light. The activation of the drug induces oxidative breakdown, producing reactive oxygen species, which in turn triggers a cascade of oxidization of biomolecules, eventually leading to cell destruction. PDT shows its biologic effect through several mechanisms including direct cell apoptosis, necrosis through vascular shutdown, and, in the long term, inducing tumor-specific immune responses.

Our Institute and several other research groups are developing this technology to apply to the treatment of cancer of the head and neck. One of the limitations of PDT is the depth of penetration of light. When tumors are illuminated from the surface, the therapeutic effect is observed 8 to 10 mm deep with temoporfin-mediated PDT. This depth varies with different photosensitizers. Many of the cancers of the head and neck and especially recurrent cancers are deeper than 5 mm, which is our cutoff depth for surface illumination leaving a safety margin of at least 3 to 5 mm. To overcome this adversity, light sources can be implanted in the cancer.

HISTORY

Previous treatments to the neck area need to be questioned in detail to ensure that any conventional treatment is not applicable. Diseases that might be exacerbated with light such as psoriasis or systemic lupus erythematosus should be ruled out before the patient is considered a PDT candidate. Swallowing function and difficulties with speech should be questioned to anticipate further problems after the treatment.

PHYSICAL EXAMINATION

The location of the cancer and its relation to vital structures should be evaluated with direct examination and flexible endoscope. During examination, special attention has to be given to any possible synchronous tumors of the aerodigestive tract. The neck should be palpated to rule out any regional lymphatic metastasis.

INDICATIONS

There is not enough evidence yet to propose iPDT as a curative treatment for primary cancers. The main application of iPDT thus far is in the treatment of cancer in cases where standard treatment methods are no longer applicable or would cause unacceptable morbidity that would incapacitate the patient. The best

examples are patients with multiple primary cancers. These patients have usually undergone extensive surgical resection of upper aerodigestive tract cancer with reconstruction, often in combination with post operative (chemo) radiation. Sometimes they even had another surgical resection or reradiation for recurrence or a second primary cancer. In such cases, the area is so extensively operated and radiated that no further treatment option is possible in case of another primary cancer, except for palliative chemotherapy. Systemic treatments for localized cancer such as chemotherapy can be avoided by treating these patients with iPDT, provided that there are no distant metastases. iPDT has several advantages in such situations. The treatment is local, thereby avoiding systemic side effects. It is executed in one session; it can be repeated as necessary. As experience builds up and methods become refined, iPDT may take its place as a primary treatment option.

CONTRAINDICATIONS

Since iPDT is a local treatment, systemic disease with distant metastasis is not suitable. Tumors invading a major blood vessel have a risk of bleeding after iPDT. The tumor has to be technically suitable for iPDT. This is explained later in the text.

PRETREATMENT PLANNING

The main purpose of preoperative evaluation is to determine whether the entire gross tumor volume (GTV) can be treated with PDT. Therefore, the recurrent or residual disease should be locoregional without distant metastasis. The screening protocols for distant metastasis vary from center to center. Chest radiographs, chest computed tomography (CT) scans, abdominal ultrasound (US), bone scintigraphy, and whole body positron emission tomography (PET) are methods that can be employed to rule out distant metastasis.

Once it is determined that the recurrent disease is locoregional, the cancer has to be adequately visualized for treatment planning. Magnetic resonance imaging (MRI) is the imaging tool of choice for oral cavity and oro-/nasopharynx cancer providing the clearest delineation of the neoplastic tissues. MR images help us to determine if technically all of the cancer can be implanted with light sources and if iPDT would cause a hazard to vital structures, for example, if there is a risk of carotid blowout. In case MRI is not possible (e.g., claustrophobic reaction), PET registered CT can be used for this purpose.

US of the neck combined with fine needle aspiration (FNA) biopsy helps to stage the regional disease.

PRETREATMENT COUNSELING

The photosensitivity caused by systemic photosensitizers requires that the patients receive adequate counseling to prevent complications due to light exposure. The duration of photosensitivity is dependent on the photosensitizer and can range from a few hours to 6 weeks. The agent that we use in our institute, temoporfin, has a photosensitivity of 2 weeks. The patients receive instructions about avoidance of light. Every day, the patient can be exposed to more light according to the guidelines provided to the patient. The patients are supplied with a light meter to measure ambient light before the procedure. They can measure light in their living quarters and adapt the brightness by hanging extra curtains, changing the light bulbs to less powerful ones, or simply avoiding the too bright rooms. The patients keep the light meter during the posttreatment period to be able to measure and adapt the ambient light. After 4 days, normal room lighting can be easily tolerated. However, daylight has to be avoided for at least 3 weeks.

The patients also receive information about airway management, feeding, and other aspects of the postoperative course.

SURGICAL TECHNIQUE

Treatment Planning

It is essential that the entire GTV plus at least 5-mm margins around the cancer are adequately treated. Having a simulated (pretreatment) plan and the means to execute it helps the clinician immensely.

In the oral cavity and oropharynx level, MR images generate the clearest impression of the cancer. The planning is very similar to that of ionizing brachytherapy. Customized brachytherapy software is used to plan iPDT. The point sources of radiation are replaced by linear array of light-emitting point sources produced by a linear diffuser. Various photosensitizers have various activation wavelengths. Treatment light wavelength is

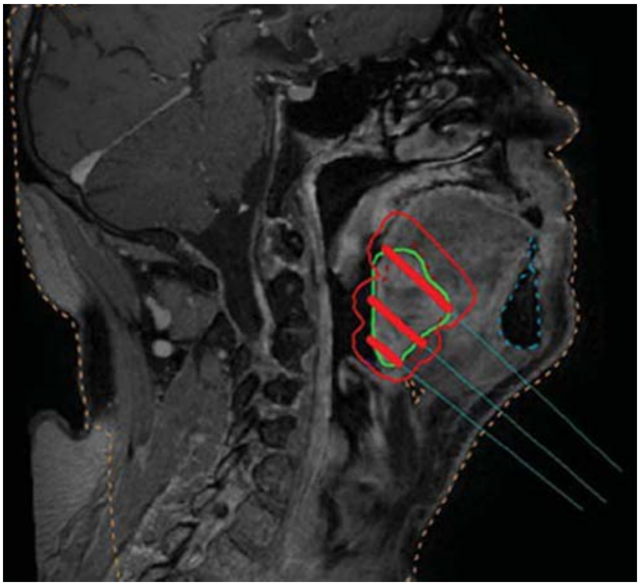

FIGURE 11.1 The cancer is identified on MR images and delineated (*the green line*). The number of light sources (*red cylinders*) necessary to illuminate the GTV with margins is planned. The light sources are virtually turned on (simulation) to ensure adequate light coverage with margins (*the red line* around *the green line*).

one of the factors that determine the penetration of light and therefore the treatment depth in regard to the light source. Temoporfin has an activation wavelength of 652 nm (red light). The mean treatment depth is 8 mm. The light sources are planned to lie parallel to each other, at a distance of not >15 mm, to provide complete coverage of GTV plus margins. The planning provides us with an adequate idea of the number of light sources necessary to be implanted, their corresponding lengths and position. The illumination phase can be simulated; in other words, the light sources can virtually be turned on, to see if there is any geographic miss, which can thereafter be corrected by modifying the planning (Figs. 11.1 and 11.2).

Photosensitizer Administration

The photosensitizer used for iPDT in our institute is injected into a deep vein 4 days before the illumination procedure. The skin is immediately light sensitive after injection. The patients can leave the hospital to return on the day of the treatment.

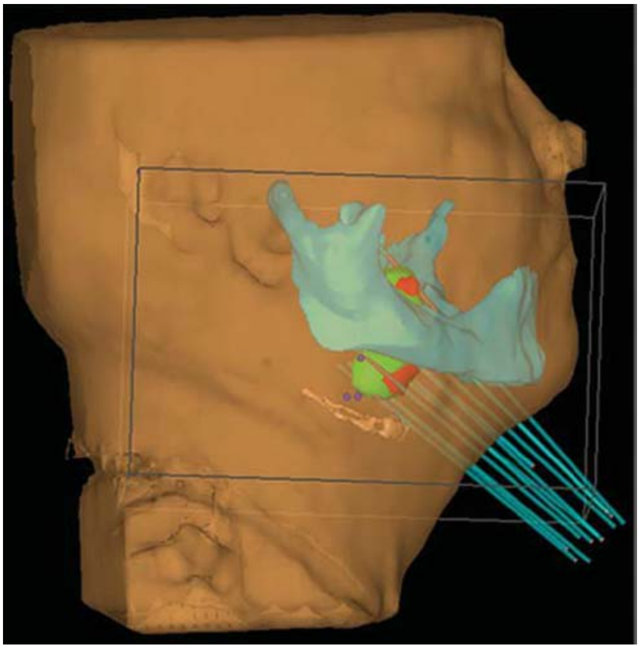

FIGURE 11.2 A three-dimensional reconstruction of the simulation. The mandible and the hyoid are marked to determine optimal catheter insertion angles.

Preillumination Preparation

Many of the patients who are candidates for iPDT have received extensive treatment to the upper aerodigestive tract. Therefore many patients already have impaired swallowing and/or airway functions. When iPDT is applied to a cancer located in the upper aerodigestive tract (thus excluding cancer located in the neck), substantial edema follows impairing the airway patency and swallowing function. Therefore, it is advisable to perform a tracheostomy and introduce a feeding tube in such patients.

Implanting Light Sources

Implantation of light sources is usually performed under general anesthesia because of the location of the cancer. Those located in regions other than the aerodigestive tract can be implanted under local anesthesia. It is advisable to implant the light sources under imaging guidance to ensure correct placement of the planned sources. For this purpose, intraoperative CT or US can be used. Cancers that are easily palpable can be implanted using palpation alone.

Depending on the location of the cancer, various techniques can be used to implant the catheters in which the light sources are placed. The cancers located in the floor of mouth, buccal mucosa, and base of the tongue are better implanted with brachy loop catheters that penetrate from the skin surface to the oral/oropharyngeal lumen and are fixed both on the mucosa and the skin surface to eliminate shifting artifacts. The placement is best checked with intraoperative CT scan registered with the simulated plan.

Cancer located in sites where through and through placement is not appropriate or desired, such as cervical lymph nodes or tumors of the parapharyngeal space, can be implanted with sharp brachytherapy needle catheters under US guidance. In this case, even though matching with pretreatment planning images is not possible, it is advisable to follow the planned location of the light sources as much as possible.

CT Guidance

Intraoperative CT is preferable to other mentioned methods because of the better match with preoperative simulated planning, which is done on MR images. The CT images taken during implantation can be uploaded to the planning software to simulate the treatment with actual catheter positions (Figs. 11.3 and 11.4). Therefore the verification of adequate light coverage of the tumor is made possible. In case the implanted catheters do not match the simulated plan, the length of the light sources can be adapted and additional catheters/sources can be placed to achieve the treatment goals.

Ultrasound Guidance

This is an easily applicable and less complex method that can be applied to cancers that are easily delineated with US. The catheters can be implanted much like performing an US-guided FNA (Fig. 11.5). It is important to use brachytherapy catheters that have closed tips rather than hollow needles to prevent blood seeping in and blocking the treatment light.

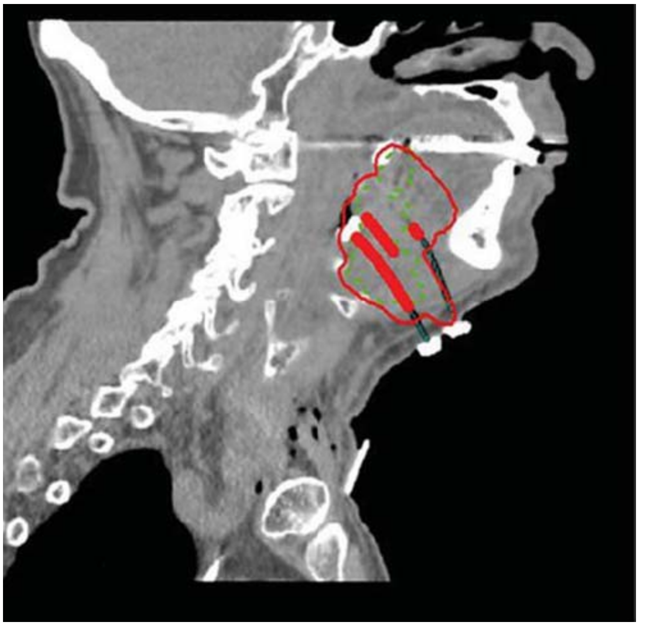

FIGURE 11.3
Intraoperative CT can help to confirm the placement of treatment catheters. The air-containing catheters are clearly visible. The tracts of the catheters can be virtually loaded with light sources, and a confirmation simulation can be performed.

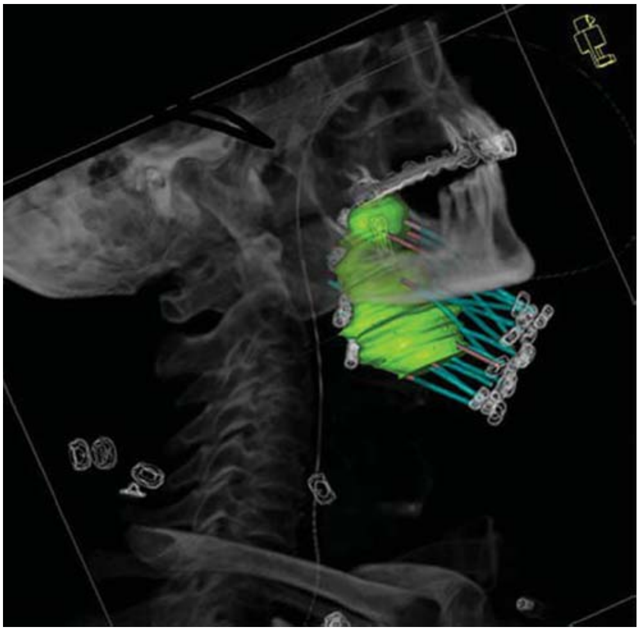

FIGURE 11.4 A three-dimensional reconstruction of the confirmation simulation with the actual catheter locations.

Tactile Guidance

In the absence of imaging guidance, the catheters can be implanted by palpation only, provided that the cancer is easily palpable. Although somewhat less accurate than CT guidance, this technique is easily applicable. In cases where the catheters do not penetrate through and through, such as lymph nodes, implantation with tactile guidance is not recommended, because the depth of implantation cannot be guaranteed to cover the tumor volume.

Illumination

Illumination protocols are directly dependent on the type of photosensitizer used. Various photosensitizers have various activation light wavelengths and fluence (the energy delivered via light). For temoporfin-mediated iPDT, the light source is a 652-nm diode laser. This is a nonthermal laser in the red light range. Four linear diffusers can be connected to the laser and used simultaneously to deliver light. The length of the diffuser's light-emitting section is determined by the pretreatment planning. The length can be fine-tuned by introducing metal shielding tubes over the diffusers (Fig. 11.6). The diffusers are introduced into the placed catheters. It is very important that the catheters do not have blood in them since hemoglobin is an important light absorber at this wavelength and works like a filter. If blood accidentally penetrates the catheter, this needs to be flushed with saline solution before the illumination. Preferred illumination fluence is 30 J/cm of diffuser length. So a 4-cm diffuser would deliver 120 J. The illumination takes 300 seconds with a fixed fluence rate. Multiple

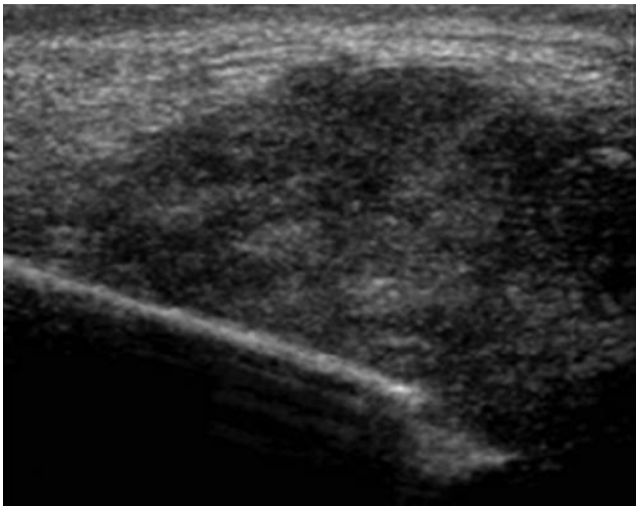

FIGURE 11.5 The tumor can be visualized and catheters placed under US guidance. The catheter is clearly visible to penetrate to the border of the tumor.

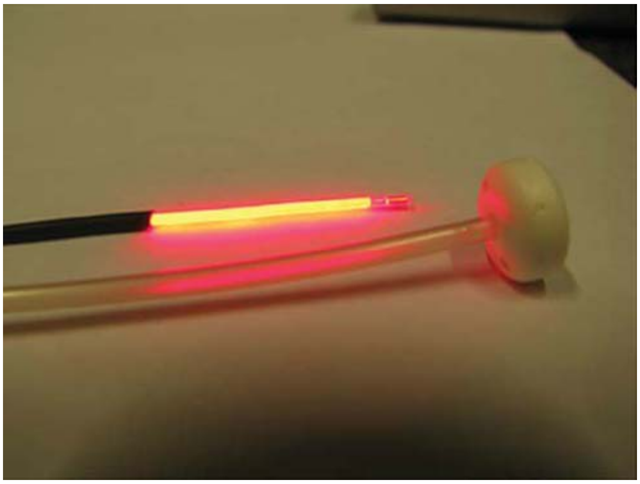

FIGURE 11.6
Linear diffuser with a black shielding tube to adjust the length of light delivery. Next to the diffuser is a catheter that will be placed through the cancer. The diffuser goes in the catheter.

diffusers can be used simultaneously (Fig. 11.7). The normal tissue should be protected with metal shielding tubes introduced over the diffusers and green drapes or black wax in the oral cavity to shield the mucosal surface opposing the cancer.

Once the illumination is complete, the catheters can be removed.

Postoperative Management

The patients remain admitted for 5 to 10 days, depending on the tissue reaction and their general condition. The posttreatment course included marked edema and pain, which peak at the first posttreatment day and subside gradually. In many cases, the tracheostomy tube can be removed 7 days after treatment. Some patients might remain tracheostomy dependent, which is related to the extent of the treatment and previous treatments. In the first 2 to 3 days, nasogastric tube feeding is helpful, but the tube can subsequently be removed. Some patients might remain tube feeding dependent.

Pain and edema can be controlled by administering corticosteroids and opioids routinely for 3 weeks and thereafter as needed.

Evaluation of Response

Once the edema subsides 1 to 2 weeks after the treatment, the cancer (if in a visible location) can be observed to turn pale and start to become necrotic. In the following 2 to 3 months, necrosis of the cancer becomes obvious with pieces of necrotic tissue becoming detached. This process is dependent on the size of the treated cancer and can take up to 5 months. The response is routinely determined at 3- and 6-month posttreatment time points. Communication with the radiologist is crucial, as necrosis at 3-month posttreatment can easily be confused with residual cancer and even some cases interpreted as cancer progression. Differentiating vital malignant tissue from necrosis is essential. At 6 months, the effect of the treatment is more obvious, presenting as tissue defects where the cancer previously existed.

FIGURE 11.7
Simultaneous illumination of four diffusers.

COMPLICATIONS

Phototoxicity

As long as the patients keep within the guidelines provided, phototoxicity reactions are rare. If any part of the skin gets exposed to sunlight for an extended time, within the first 2 weeks following photosensitizer administration, the patient will get a second- or third-degree burn. The treatment is essentially the same as for any burn.

Bleeding

As necrotic tissue detaches, it could be accompanied by minor bleeding. Major bleeding is uncommon because of the vascular shutdown effect of iPDT. Management of bleeding is with standard hemostasis measures. In case of major bleeding, intra-arterial embolization should be considered.

Tissue Defects

The major tissue effect of iPDT is necrosis during which time pieces of necrotic tissue become detached and with time are removed. The end result is a tissue defect. Depending on the extent and location of the treatment, there could be through and through defects between the skin and the oral cavity or oropharynx. Therefore it is crucial to protect the uninvolved tissue from the treatment light.

RESULTS

The simulated planning is based on an assumed standard distribution of light in the tissues. However, the distribution of light depends on the optical properties of the tissue and varies greatly in different tissue types. Measuring emitted light from the catheters surrounding the treatment catheter and building a model to represent light distribution would be a better option. The photosensitizer emits fluorescence, which can be measured with spectroscopy techniques. Measuring the change of fluorescence delivers information about the ongoing process at the cellular/molecular level. Research is under way in both mentioned lines, and the results will help us to fine-tune our treatment program.

PEARLS

- Patient selection is crucial.
- Locoregional disease, which can completely be illuminated, has to be confirmed with adequate imaging.
- Have a plan and execute the plan in the operating room.
- Always use catheters that are closed at the tip to prevent blood from seeping into the catheter.
- Be prepared to manage airway, feeding, and wound problems.

PITFALLS

- Failure to protect normal tissues from light will result in undesired damage.
- Presence of blood around the light sources will act as a filter and limit the treatment effect.

INSTRUMENTS TO HAVE AVAILABLE

- Brachytherapy catheters
- Brachytherapy trocars
- Guidewire
- Fixation buttons
- Shielding tubes to slide over light source
- Diode laser of fixed or adjustable wavelength
- Linear light diffusers
- Shielding (dark-colored drapes or black wax)
- Rigid pharyngoscope
- Mouth gag

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van Leeuwenhoek Hospital, Amsterdam, The Netherlands; Prof. H.J.C.M. Sterenborg, PhD, R.L.P. van Veen, Bs PhD, J.B. Aans, BEng, Center for Optical Diagnostics and Therapy, Erasmus MC, University of Rotterdam, Rotterdam, The Netherlands.

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12 TRANSORAL EXCISION OF CANCER OF THE TONSIL

Roberto A. Lima

INTRODUCTION

Cancer of the oropharynx represents 10% to 15% of all cancers of the head and neck. Most of these cancers (50%) occur in the tonsil region, including the tonsil, tonsil fossa, and tonsil pillars.

Unfortunately, most of these cancers are identified in advanced stages. The indolent progression, as well as large number of lymphatics, and a common confusion with infection have been suggested as to why these cancers are diagnosed in advanced stages.

The use of radiotherapy alone or chemoradiation has been the primary treatment option in many centers around the world. Recently the association of cancer of the oropharynx with human papillomavirus has been described and explains the increased incidence of this tumor in young patients.

The tonsil fossa, which contains the tonsil, is limited by the anterior tonsillar pillar (palatoglossus muscle) and the posterior tonsil pillar (palatopharyngeal muscle).

Lateral to the tonsil fossa are the pharyngeal muscles, the mandible, and the parapharyngeal space. The carotid artery is just lateral and posterior to the tonsil fossa. In this region, special care should be taken to avoid injury to these structures (Fig. 12.1).

HISTORY

Most cancers of the oropharynx are diagnosed in advanced stages. Unfortunately, symptoms produced by the cancer are similar to the infections commonly occurring in this area. A vague, suggestive discomfort, scratchy feelings, and minor otalgia are often treated with antibiotics without a diagnosis for some months. The occurrence of a cervical mass is the primary symptom in 25% of the patients.

The occurrence of pain in the throat, mainly while swallowing, is a very common symptom along with the occurrence of otalgia which is caused by invasion of the glossopharyngeal nerve. The pain reaches the ear by connections with the petrosal ganglion and Jacobson (tympanic) nerve. The occurrence of bleeding and trismus is more common in cases of advanced cancer. Voice changes can be present in cases of invasion of the base of the tongue.

PHYSICAL EXAMINATION

A careful clinical examination must be done with inspection and palpation including the parapharyngeal space for correct staging of the primary cancer of the oropharynx and the neck. Infiltration of the oral tongue, the base of the tongue, and the vallecula is identified by palpation. Many times this infiltration is submucosal, preventing direct visualization. This examination is very important before the surgery because invasion of these structures is a contraindication to surgery.

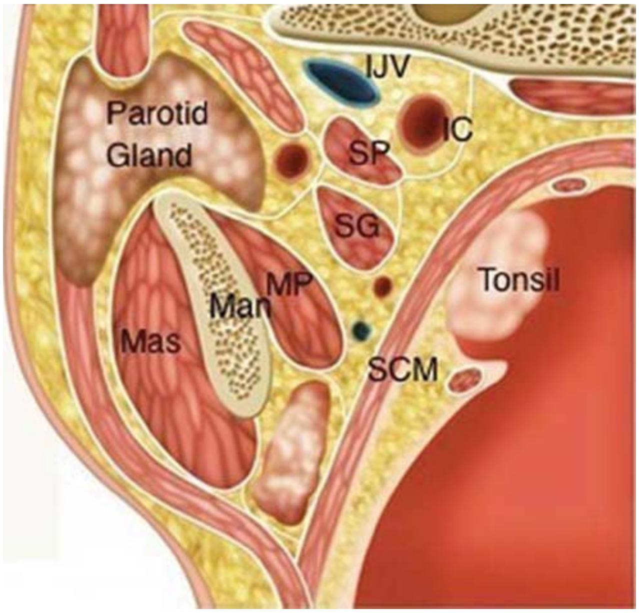

FIGURE 12.1
Anatomic structures located in the tonsil region. IC, internal carotid artery; IJV, internal jugular vein; Man, mandible; Mas, masseter muscle; MP, medial pterygoid muscle; parotid gland; SG, styloglossus muscle; SP, stylopharyngeus muscle; SCM, superior constrictor muscle; and tonsil.

INDICATIONS

Squamous cell carcinoma of the tonsil can be adequately resected through the oral cavity. However, some characteristics should be respected. The stage of the cancer (T1/T2) is most important; we understand that advanced cancer is a formal contraindication because of the relationship between this region and the carotid artery and mandible laterally.

Some authors have reported their experience with resection of more advanced cancer of the tonsil fossa, even for T3 lesions. One study included a series of 166 cases using an incision in the mucosa of the anterior pillar reaching a dissection plane between the buccinator and the superior constrictor muscle using the superior constrictor muscle as the deep margin (Fig. 12.2).

In some cases, metastasis to the cervical lymph nodes may be the first symptom of a very small cancer of the tonsil. In these cases, the tonsil can be resected through the oral cavity and a neck dissection performed at the same sitting.

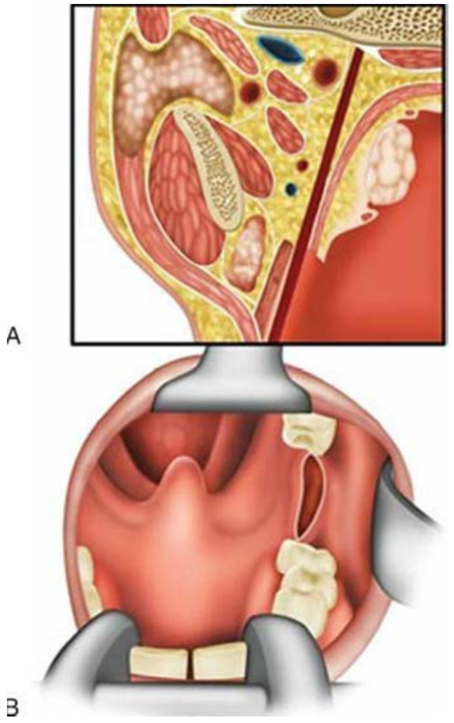

FIGURE 12.2
A: The dark line demonstrates the dissection plane to reach a safe margin and protect the internal carotid artery. **B:** The incision should be done on the pterygomandibular raphe, where the buccinator muscle and superior constrictor are fused.

Recently, new devices have been used to facilitate the hemostasis (harmonic scalpel) and to facilitate the posterior view of the cancer allowing for wider resection. The depth of tumor infiltration is also important because of the presence of the internal carotid artery in that region.

CONTRAINDICATIONS

Cancer of the tonsil in patients with high risk for general anesthesia should be treated with radiotherapy or radiotherapy and chemotherapy according to the stage of the disease. Cancer in moderately advanced stages such T3 or advanced T4 is a formal contraindication. In general, this tumor invades deep structures and should be removed through mandibulotomy or mandibulectomy approaches, usually along with neck dissection. Other contraindications include cancer reaching the soft palate and/or the base of the tongue.

PREOPERATIVE PLANNING

The computerized tomography or magnetic resonance imaging should be used not only to evaluate the stage and the extent of the cancer for deep structures but to identify the presence of subclinical metastasis in the neck and metastasis to the retropharyngeal lymph nodes.

The best initial treatment for cancer of the oropharynx is controversial. The development of transoral techniques allowing primary resection of tonsil with reduced morbidity is leading some surgeons to choose primary surgical treatment.

SURGICAL TECHNIQUE

Preparation

General anesthesia is induced through a naso- or orotracheal tube. The patient should be advised about the possibility of a tracheostomy, if necessary to prevent postoperative respiratory distress.

The position of the patient on the operating table is similar to the position for oral resections, with the proper mouth gag, or the position used for a normal tonsillectomy, with hyperextension of the neck, along with the use of a mouth gag.

However, if there is a plan to perform a neck dissection, the common position for oral resection should be used to prevent position changes during the surgery. I prefer this position because of the high incidence of neck metastasis in cancer of the oropharynx leading to the inclusion of a neck dissection along with the resection of the primary cancer. I believe the correct use of the mouth gag gives good exposure of the tonsil fossa.

INTRAOPERATIVE TECHNIQUE

After good exposure of the tonsil area is obtained, the tumor should be visualized (Fig. 12.3A and B) and its limits should be drawn with a 1-cm margin (Fig. 12.4A and B).

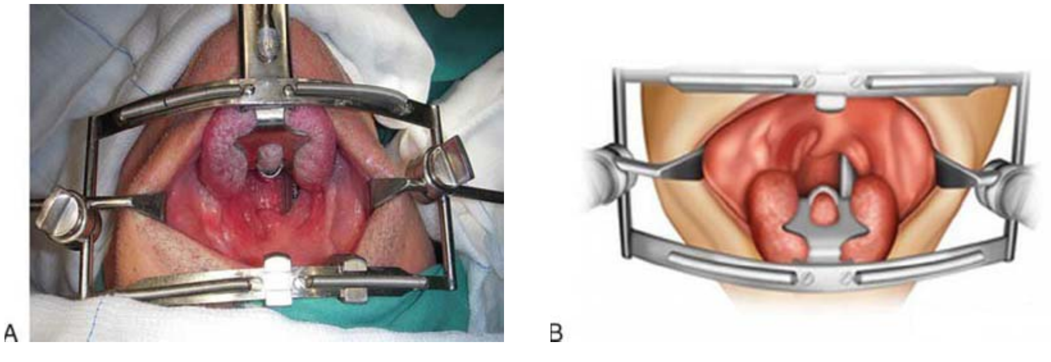

FIGURE 12.3
A,B: Proper exposure of the oropharynx using the Dingman mouth gag is important for a safe resection.

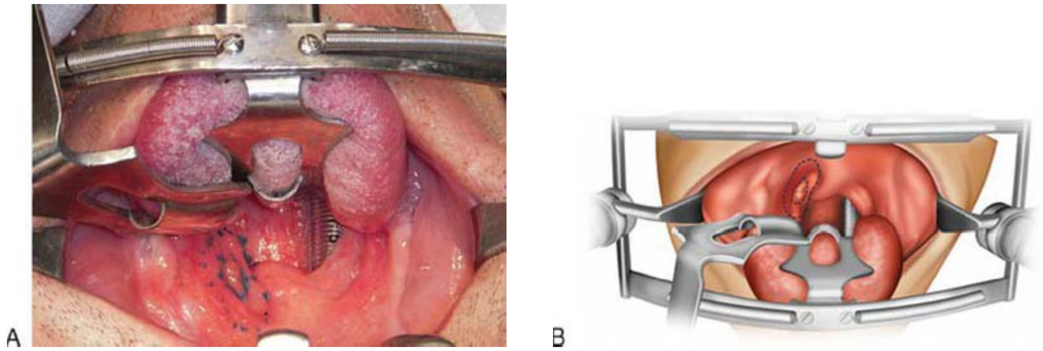

FIGURE 12.4
A,B: After adequate exposure, the T1 cancer is outlined. For small and superficial cancers, a primary resection offers good surgical margins.

Using an electrocautery, a careful incision is made deep enough to identify the superior constrictor muscle (Fig. 12.5A and B). This muscle is carefully sectioned and a submuscular plane appears. This plane should be dissected carefully preventing injury to the carotid artery. After the tumor resection, the surgeon is able to identify the deep limit (Fig. 12.6A and B).

As soon as the cancer-free margins have been identified by the pathologist on frozen section, meticulous hemostasis through the incisions into both the mucosa and underlying pharyngeal musculature must be performed layer by layer with bipolar electrocautery to achieve initial, complete hemostasis of the numerous small venous and arterial vessels that will be encountered. Closure of the surgical wound is done with absorbable sutures (Fig. 12.7A and B).

POSTOPERATIVE MANAGEMENT

In patients who need a tracheostomy postoperatively, the tube should be removed after a careful examination of the oropharynx to identify possible edema in the area of the resection. In patients without edema, the tracheotomy cannula is removed on the second postoperative day.

I usually do not use nasogastric tube in our patients. The feeding can usually be initiated on the first postoperative day with a cold liquid diet. If the patients tolerate this diet without problems, we begin a pureed diet on the second day.

It is important to keep the oropharynx and oral cavity clean during the early postoperative days. The patient should have a careful mouthwash with the appropriate solution until the resected area is healed.

During the initiation of swallowing, the patient should be treated by a speech therapist controlling possible aspirations or respiratory distress. Usually we discharge the patient home after 2 days of normal respiratory and swallowing functions.

COMPLICATIONS

The occurrence of postoperative bleeding is the main complication. The patient who does not have tracheotomy should have it, as soon as possible, and hemostasis should be performed in the operation room. Some patients

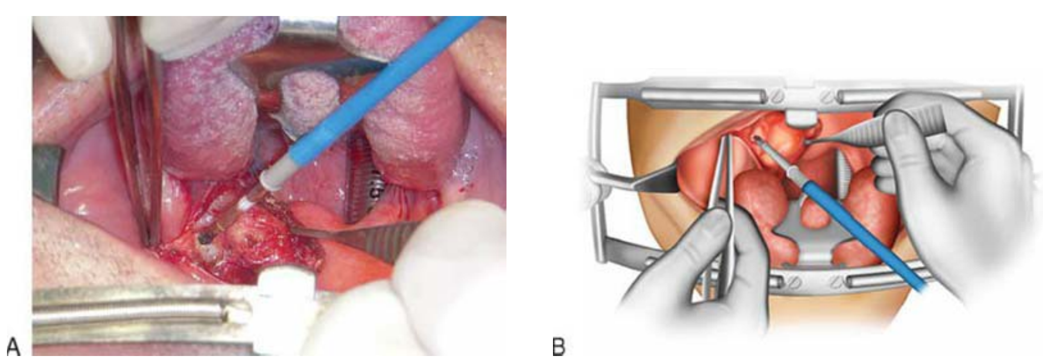

FIGURE 12.5
A: The use of a long-tip electrocautery permits better access to the tonsillar region. **B:** A careful incision is made deep enough to identify the superior constrictor muscle.

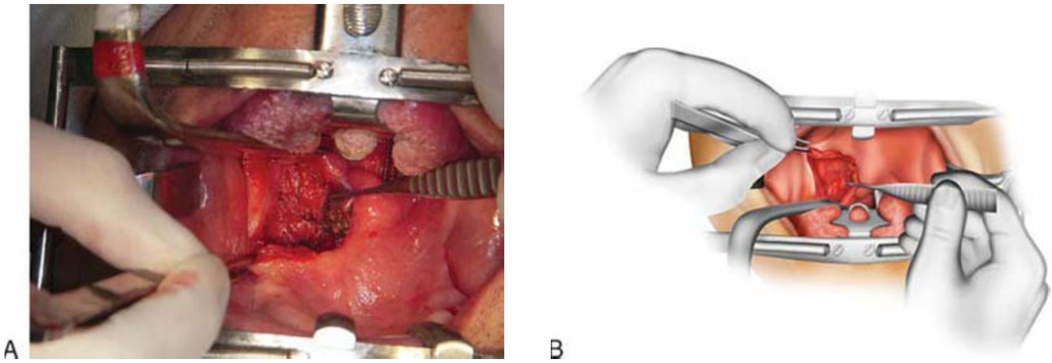

FIGURE 12.6
A,B: After the superficial tumor resection, the deep margin is the superior constrictor muscle.

can have difficulty swallowing in the immediate postoperative day, and they should be followed by a speech therapist.

RESULTS

Published articles show an 83% to 89% 5-year survival, according to T and N stage.
No cases of permanent gastrostomy, nasogastric tube, or tracheostomy have been reported.

PEARLS

- Use of imaging prevents wrong indications.
- Correct staging improves successful results.
- Correct deep dissection avoids unnecessary bleeding.

PITFALLS

- Underestimation of the depth of invasion by the cancer can lead to massive bleeding.
- Inadequate exposure of the cancer prevents obtaining a good margin of resection.
- Advanced cancer, T3 or T4, usually are contraindications.

INSTRUMENTS TO HAVE AVAILABLE

- McGivor or other mouth gag
- Cautery with a long tip
- Long surgical instruments

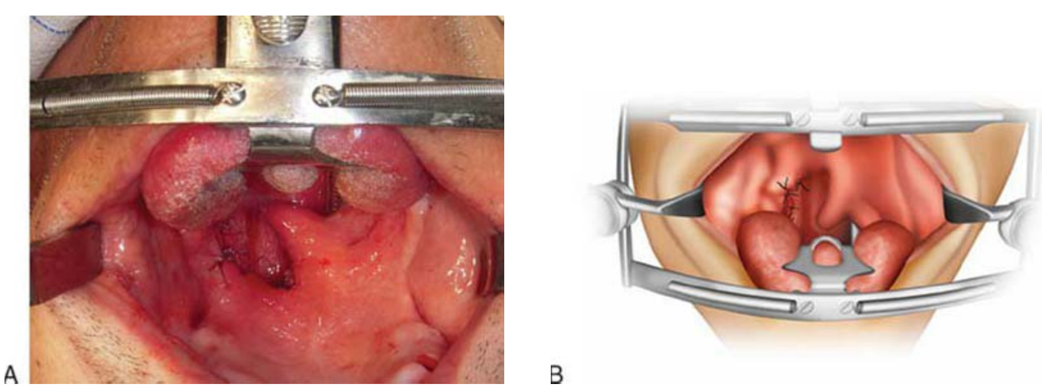

FIGURE 12.7
A,B: As soon as the margins have been checked by frozen section, the wound is sutured. After resection of a small cancer, it is possible to close the wound with little distortion of the normal anatomy.

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13 TRANSORAL ROBOTIC SURGERY (TORS) FOR CANCER OF THE TONSIL

Bert W. O'Malley Jr

INTRODUCTION

Many otolaryngologists believe that surgery for squamous cell cancer of the oropharynx is not routinely performed and that almost all patients are treated either with radiation alone or with chemoradiation. Over the past 30 years, radiation or chemoradiation has become the therapy most commonly recommended for the treatment of the majority of patients with cancer of the tonsil. The rationale for advocating nonsurgical therapy for advanced cancer of the tonsil was to avoid the significant morbidity associated with classic open approaches to the tonsil and the base of the tongue. These invasive open surgical techniques might include a lip-splitting incision, a mandibulotomy, major resections of noninvolved muscles and other soft tissues, tracheostomy, and the need for microvascular free flap reconstruction. However, in order to achieve similar oncologic outcomes for chemoradiation versus classic open surgery and postoperative adjuvant therapy, the radiation doses and volumes have been escalated in conjunction with multidrug chemotherapy regimens. Machtay et al. analyzed the late sequelae of all long-term survivors of chemoradiation in previously completed Radiation Therapy Oncology Group (RTOG) trials and found that 35 of 101 (34.6%) surviving patients with advanced oropharynx cancer had severe late toxicities (i.e., noncancer deaths attributable to treatment, fistula, tracheostomy, long-term feeding tube) following chemoradiation. In addition, a review of the literature in a recent publication about transoral robotic surgery (TORS) for oropharyngeal cancer identified a range of 8% to 38% chronic or long-term percutaneous gastrostomy (PEG) dependence in patients who received state-of-the-art intensity-modulated radiation therapy in combination with chemotherapy. These not-uncommon side effects raised the question as to whether less invasive surgical techniques would prove equally as effective oncologically with fewer functional sequelae than the current state-of-the-art chemoradiation regimens.

The surgical robot that is commercially available and used for current TORS procedures is the da Vinci robot (Intuitive Surgical, Sunnyvale, CA) (Fig. 13.1). The key benefits of the surgical robot include the high-magnification and three-dimensional optics that allows careful dissection, and identification of nerves and vessels, which facilitates en bloc resection. In addition, the instruments most commonly used are 5 mm in size and can be readily moved and manipulated within the oropharynx by the primary surgeon sitting at a remote console (Fig. 13.2). These small robotic instruments provide over 360 degrees of freedom of movement while allowing motion scaling and providing total tremor filtration, which adds significant precision to the surgical procedures. In addition to the primary surgeon operating from the console, there is ample room for a bedside assistant surgeon to also provide transoral suctioning and retraction with instruments in both hands. Thus, in principle, TORS is similar to the classic two-surgeon, four-handed surgery, except that it is performed using the robot. Specific steps and concepts that allow for safe and complete resection of cancer of the tonsil are outlined below.

Published studies from human trials have demonstrated both the feasibility and safety of TORS for cancer of the upper aerodigestive tract. These TORS procedures are associated with limited surgical morbidity, reduced hospitalization, and enhanced patient functional outcomes, particularly in swallowing, over present chemoradiation therapies. The long-term PEG dependency rates after TORS, in a series of patients

FIGURE 13.1
Photo of robot.

with advanced oropharyngeal cancer treated with TORS followed by neck dissection and adjuvant therapy as indicated, at the University of Pennsylvania have ranged from 2.4% versus 8% to 38% for chemoradiation for similar patient cohorts.

Another factor to consider is the growing number of patients with cancer of the tonsil who have human papillomavirus (HPV) as an etiologic factor. These patients who are HPV positive have significantly improved cure rates when compared to patients who are HPV negative using radiation or chemoradiation strategies. Furthermore, the primary cancers are characterized by lower T stage in general, which are amendable to transoral resection. In our recent cohort study on the benefit and outcomes of TORS based on HPV status, we achieved equally successful high rates of survival and tumor control regardless of whether a patient is HPV positive or negative. For patients who are HPV positive, it may be a reasonable consideration to investigate "de-escalation" of therapy, and TORS for cancer of the tonsil may find a role in this concept.

HISTORY

The classic history for patients with squamous cell cancer of the tonsil from previous decades was that of a heavy smoker or smoker and drinker, typically a pack per day or more over 10 years with varying degrees of alcohol intake reported. In our present decade, the history has shifted to include an ever-increasing number of patients who report no smoking, or smoking in the distant past, and have a minimal history of alcohol intake. As mentioned above, these patients have a cancer, which is HPV positive, and thus the cause of their cancer is attributed to this viral infection, which occurred an estimated 20 to 40 years prior to the cancer.

FIGURE 13.2
Photo of the 5-mm instruments.

This widespread prevalence is a key reason why oropharyngeal cancer is one of the most rapidly increasing cancers in the United States.

It is important to take a thorough past history on patients with an emphasis on the smoking and alcohol consumption. If the patient has significant medical comorbidities, then medical or cardiac clearance is always warranted. It is also important to perform HPV testing or its surrogate p16 expression by immunohistochemistry on fine needle aspirations of metastatic lymph nodes or biopsies of the primary cancer of the tonsil. The knowledge of HPV involvement may help drive the options of therapy, such as the consideration of de-escalated or minimally invasive combination therapies.

PHYSICAL EXAMINATION

A thorough examination of the head and neck is warranted, with particular attention to the size and extent of the primary cancer of the tonsil using transoral direct visualization and indirect laryngoscopy. Extension of the cancer of the tonsil into the nasopharynx or to the midline of the posterior pharyngeal wall is considered contraindication to TORS. While it is technically feasible to completely resect these more extensive cancers, I believe that the magnitude of removal of the constrictor muscle puts the patient at greater risk of near-term postoperative as well as persistent dysphagia, which is a complication of chemoradiation that TORS was intended to reduce.

The neck is palpated to identify lymph node metastases and allow basic clinical determination of fixation, which suggests the presence of extracapsular spread of the metastatic cancer. Another key clinical finding to evaluate is the presence of trismus, which is indicative of extension beyond the constrictor muscles into the pterygoid muscle. Extensive involvement of the pterygoid muscle is a contraindication to TORS, although minimal invasion of the medial pterygoid muscle is acceptable for TORS approaches.

INDICATIONS

Indications for TORS at the University of Pennsylvania have been based on the desire to ensure (1) a high percentage of cancer-free surgical margins; (2) excellent, reproducible, functional outcomes; (3) healing by secondary intention or if there is a soft palate defect, bone exposure, or carotid exposure, then use local flaps rather than free flaps; and (4) safety from the perspective of the major vasculature. I suggest that the reader keep these concepts in mind when reviewing our suggested indications and contraindications for TORS radical tonsillectomy.

The indications for TORS for cancer of the tonsil start with the ability of a patient to undergo surgery in general. In general, all T1, T2, T3, and selected T4 cancers as defined by the American Joint Committee on Cancer (AJCC) are amenable to TORS.

CONTRAINDICATIONS

In general, I consider patients with Stage IVc as not being candidates for surgery except if they have a solitary or curable pulmonary or other distant metastasis. In addition, the following are considered contraindications for TORS:

Cancers that are T4a except for cases where there is limited unilateral involvement of the ipsilateral base of the tongue or medial pterygoid muscle. This is assessed on physical examination, typically under general anesthesia, and is not a radiologic diagnosis.

Although deep extension across the midline of the base of the tongue is a contraindication for TORS based on the contention that bilateral resection of the base of the tongue could devascularize, the tongue and that loss of much greater than half the deep tongue base may be functionally debilitating. Of note, superficial extension of cancer (i.e., mucosal involvement without deep muscle invasion) to the contralateral tongue base is not a contraindication to TORS.

AJCC T4b tumors indicate cancer extension into the lateral pterygoid, or encasement of the carotid artery, or significant bone invasion. For patient safety considerations in the TORS approaches, I feel that any cancer, which abuts the internal carotid artery or carotid bifurcation, should be considered a contraindication. While some authors have advocated the use of free flap reconstruction following wider resections with TORS, it is our contention that since squamous cell carcinoma that abuts the carotid system may be adherent, dissection of the carotid transorally should be avoided.

Involvement of the pharynx at, or across, the midline, extension into the nasopharynx, or invasion of the prevertebral fascia are contraindications. It is important to note that while this lateral or deep invasion may be identified on computed tomography (CT) or magnetic resonance imaging (MRI), nevertheless palpation of the cancer under anesthesia is critical to confirm these findings.

In my opinion, if a patient must receive chemoradiation for an unresectable neck metastasis, then the patient should undergo the same treatment for the primary cancer of the tonsil.

There are also non–cancer-related contraindications for TORS given the nature of its transoral minimally invasive approach. These nontumor contraindications are as follows:

Non–cancer-related causes of trismus or other factors that limit mandible excursion and thus limit achieving adequate transoral access.

The presence of a retropharyngeal internal carotid artery in which the artery is located directly behind the tonsil fossa. TORS resection would not only put the internal carotid artery at risk but would expose it, requiring some type of local or other tissue transfer or flap to cover this portion of the vessel in order to prevent rupture of the vessel.

PREOPERATIVE PLANNING

A complete history and physical examination is performed, and either CT scan with contrast or MRI with gadolinium of the neck, including the nasopharynx, is obtained.

Attention is paid to the size and extent of the primary cancer (exophytic versus endophytic) as well as the extent of nodal metastases. It is critical that the surgeon or head and neck radiologist comment on the course of the internal carotid artery and whether the tumor abuts the external, internal, or carotid bulb (Fig. 13.3). Also, when there is even minimal trismus, the cross-sectional images of the CT or MRI will help identify cancer extending laterally into the soft tissues of the parapharyngeal space or into the pterygoid musculature.

A critical aspect of the evaluation includes palpation of the tonsil fossa. In the highly cooperative patients, palpation can be done in the outpatient setting with the patient awake. The key clinical finding that must be confirmed is mobility. If the cancer in the tonsil fossa is mobile relative to the prevertebral fascia posteriorly, hamulus superiorly, and medial pterygoid muscle laterally, then this is an indication that there has been no spread of cancer beyond the constrictor muscles and the buccopharyngeal fascia surrounding this muscle. Total fixation of the tonsil is a contraindication to surgery. Hypomobile cancers can still be operated upon depending on the site of decreased mobility. If by bimanual palpation it is clear that the fixation is at the very anterior aspect of the medial pterygoid muscle and the posterior and superior aspects of the cancer are mobile, then this is an acceptable indication as long as the plan is to resect a portion of the medial pterygoid during the procedure. In my experience, approximately two-thirds of patients require a separate endoscopy for triage.

SURGICAL TECHNIQUE

The overall oncologic goal of TORS radical tonsillectomy is to use an en bloc resection approach, under high magnification, to routinely ensure a wide cancer-free surgical margin in most anatomic areas (i.e., base of the tongue, soft palate, medial and lateral mucosal margins) and avoid positive or close margins (or false-positive margins) in the deep lateral constrictor margins.

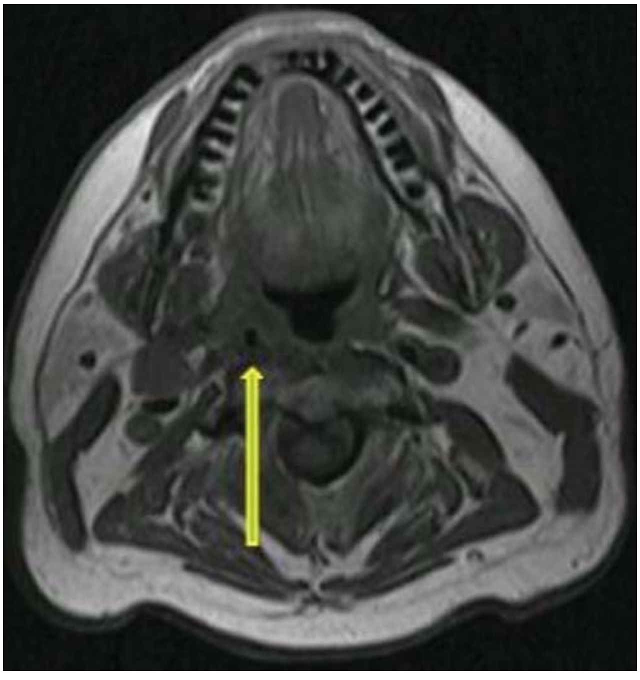

FIGURE 13.3
Photo of retropharyngeal internal carotid artery (*arrow*).

I typically use the Crowe-Davis retractor (Bausch & Lomb/Storz) as it maintains the mouth opening and retracts the oral tongue inferiorly, thus providing good visualization and wide access to the tonsil and superior aspect of the oropharynx. In all the TORS radical tonsillectomy, the minimum amount of resection of the base of the tongue is approximately 1 cm deep to ensure a wide inferior margin around the inferior poles of the tonsil. In some cases, where the cancer of the tonsil abuts or involves the base of the tongue, a wider resection of the base of the tongue is necessary. The Crowe-Davis retractor is placed so that this area of the base of the tongue is adequately exposed, and I prefer not to release and reposition the retractor and hence the exposure during the course of the surgical procedure. The retractor can be suspended using a Mayo stand or using a Storz scope holder stabilizing arm.

The robotic surgery console is brought into the field and the 0 degree three-dimensional endoscope is placed in the middle of the oral opening created by the Crowe-Davis retractor. Once the endoscope is placed centrally, the 5-mm spatula tip Bovie and Maryland dissector instruments are placed on either side of the endoscope. The Bovie instrument is initially placed on the side of the cancer to be removed.

The initial incision is designed in the shape of a question mark to ensure rapid identification of the tendon of the medial pterygoid muscle and to avoid a positive margin submucosally in the area of the lateral margin. The incision is in the mucosa overlying the pterygomandibular raphe extending to the base of the tongue inferiorly and through the inferior aspect of the soft palate superiorly to a point above the tonsil pillars that will provide a cancer-free margin around the cancer (Fig. 13.4). Dissection with the robotic instruments is aided by the bedside surgical assistant who typically is holding two curved baby Yankauer suction instruments that are used for suctioning smoke and retracting tissues.

After the initial incision, a plane of dissection is developed lateral to the body of the constrictor muscles and extended more lateral to identify the pterygoid musculature. The pad of parapharyngeal adipose tissue is identified in its location between the constrictor and medial pterygoid muscle. After identifying the pterygoids, adipose tissue pad, and constrictor muscles, the surgical dissection is carried inferiorly to identify the styloglossus and stylopharyngeus (which sits deeper) muscles. At this point, the initial excision is brought around the junction of the tonsil and the base of the tongue to include a small amount of posterior floor of mouth mucosa. There are multiple fascial planes that are encountered when performing this operation, and I recommend blunt dissection with the 5-mm instruments in order to identify tonsil arteries and veins so that they can be clipped and controlled.

After making the incisions in the glossotonsillar junction, attention moves to the soft palate to complete the incision and through and through resection that provides a wide surgical margin around the cancer. As the palate and superior tonsil pillars are incised laterally, the dissection continues posteriorly to identify the prevertebral fascia that overlies the longus colli musculature. At this point, an "index" incision is made in the medial oropharyngeal mucosa and just into the constrictor musculature (but not through it) so as to define the medial limits of the resection (Fig. 13.5). The dissection is then carried inferiorly along pharyngeal constrictors and medial to the parapharyngeal adipose tissue. It is important to preserve this if possible as this provides both dissection protection and tissue coverage over the external and internal carotid artery. During this maneuver, the medial constrictor muscle component is bluntly dissected off the prevertebral fascia to the inferior limits of the resection.

The margin at the base of the tongue is now addressed, and the extent of resection is governed by the inferior extension of the cancer of the tonsil. When there is no actual invasion into the base of the tongue, I recommend a 1-cm margin of mucosa and muscle of the ipsilateral base of the tongue. For cancers that invade the base of the tongue significantly, up to ½ of the base of the tongue can be resected with the radical tonsillectomy and partial pharyngectomy procedure without causing significant swallowing dysfunction. It is important to pay attention to the position of the endotracheal tube while dissecting medially with the pharynx and the base of the tongue so as to prevent the risk of contact and potential for an airway fire (Video 13.1). I use a wire-reinforced endotracheal tube for all TORS procedures. The bedside surgical assistant provides retraction of the endotracheal tube to the contralateral side as needed during the operation. The bedside assistant plays a key role in

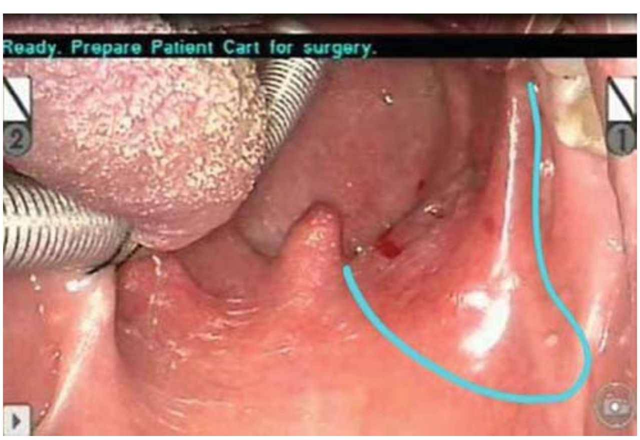

FIGURE 13.4 Incision drawing and intraoperative photograph with the incision outlined on the mucosa.

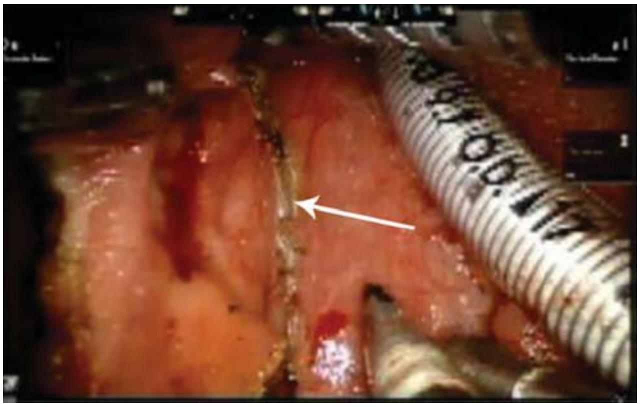

FIGURE 13.5
Medial index incision in the oropharyngeal constrictor muscles (*arrow*).

providing countertraction that will facilitate safe and effective dissection and en bloc resection. For cancers that invade the base of the tongue, the lingual artery is typically encountered while performing resection of the lateral base of the tongue. It lies lateral to the intrinsic muscles of the tongue and medial to the hyoglossus muscle coursing superior to the hyoid bone. I identify and clip the proximal and distal aspects of the artery when we are in close proximity to it regardless of whether I need to sacrifice it or not for wide surgical margins. Should the surgeon inadvertently enter the lingual artery, control is aided by suctioning from the bedside assistant as well as external pressure being applied to the neck by the assistant above the ipsilateral greater cornu of the hyoid. The artery can then be ligated from below during the neck dissection if planned.

After completing the incisions into the base of the tongue, attention returns to the styloglossus and stylo-/palatopharyngeus muscles, which are dissected and Bovie transected, leaving a margin of muscle around the junction of the tongue and constrictors. In this region, there are multiple tonsil veins and arteries that are encountered and can be bipolar cauterized or clipped. In addition, the glossopharyngeal nerve may be encountered deep to the styloglossus, and I resect this nerve if necessary or if significant dissection and exposure are required to achieve wide margins around the cancer. The parapharyngeal adipose tissue plane is preserved to protect the great vessels. However, if frozen section analysis identifies penetration of the cancer through the constrictor muscle, these planes may be further resected to achieve clear surgical margins. The resection is then completed by bringing the base of the tongue incisions and dissection to the lateral oropharyngeal wall just inferior to the stylopharyngeus muscle. The specimen can be removed en bloc upon the final through and through incisions into the constrictor muscle along the remaining course of the medial pharyngeal index incision.

The surgical specimen is then brought to the surgical pathology suite for inking and orientation performed with both the surgeon and pathologist. Frozen sections of mucosal or muscular margins are performed where the margins are deemed clinically close as determined by sectioning into the tumor and by palpation.

Once frozen section analysis is complete and cancer free margins are assured, the wound is inspected to assess for extent of soft palate resection and thus risk of nasopharyngeal regurgitation and incompetence postoperative. In general, no reconstruction is needed if the lateral mucosa at the junction of the soft palate and the posterior pharyngeal wall remains intact. In cases where there is a soft tissue defect and gap, then a pharyngoplasty is performed by suturing the posterior lateral aspect of the soft palate mucosa to the side of the superior pharyngeal muscular and mucosal incision. It is important to include some palate and constrictor musculature in the horizontal mattress suturing, or the mucosal approximation will likely tear and the lateral tissue gap may reopen. In cases where their remains a lateral tissue gap and communication with the nasopharynx after the pharyngoplasty, my recommendation is to use a pedicled pad of buccal adipose tissue for final closure (Fig. 13.6). The pad is mobilized by dissecting superior and lateral to the medial pterygoid muscular into the buccal space. The adipose tissue is then gently mobilized medially and sutured to both exposed musculomucosal surfaces of the pharynx and soft palate. If a neck dissection is planned, reinforcement from below may be created using the posterior belly of the digastric muscle or a sternocleidomastoid rotational flap.

After completing any reconstruction, the wound is inspected for bleeding for which mild oozing can be controlled with bipolar cautery. After a Valsalva maneuver from the anesthesiologist with the bag ventilation device and confirmation of no active bleeding, a thin layer of Tisseel, Fibrin Sealant (Baxter Healthcare), is applied to the surgical site.

POSTOPERATIVE MANAGEMENT

The majority of patients are extubated and receive standard postoperative care on our specialized head and neck patient floors. Tracheostomy is not routinely performed. All patients receive postoperative dexamethasone steroid intravenous (IV) at 6 mg every 6 hours until discharge. Upon discharge, the patients are prescribed a

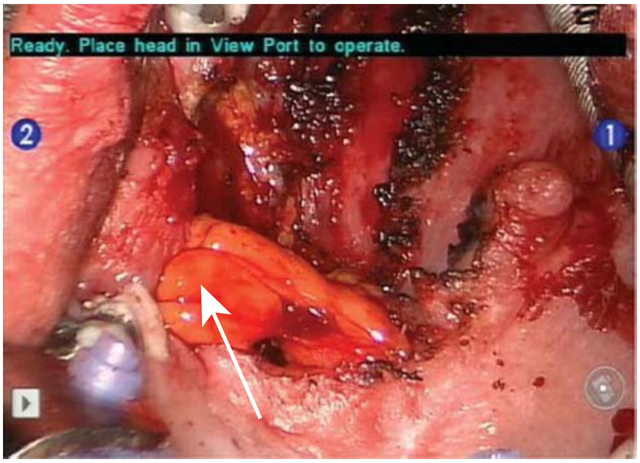

FIGURE 13.6 Buccal adipose tissue flap (*arrow*).

Medrol dose pack is prescribed. The patients also receive IV broad-spectrum antibiotics such as Ancef while in the hospital and then oral or per Dobhoff feeding tube antibiotics for 1 week postoperatively.

COMPLICATIONS

In general, the risks and nature of complications are similar to standard transoral surgery of the oropharynx or even open surgical procedures. There is a potential risk of injury to the patient from the robot itself, but in our department, we have yet to encounter this in the approximately 1000 cases.

The incidence of bleeding is similar in occurrence as with primary tonsillectomy procedures for chronic tonsillitis. I have encountered post-TORS tonsil bleeding in approximately 2.9% of patients, which falls within the lower range of reports for post-tonsillectomy bleeding (unpublished data). Most bleeding can be treated with observation or topical cautery in the clinic or emergency room. However, more active or extensive bleeding may require management with identification of the vessel(s) and Bovie cauterization under anesthesia in the operating room. I have encountered postoperative nasopharyngeal incompetence with rhinolalia or nasopharyngeal regurgitation with liquids; however, this is a very rare finding and is prevented by use of local reconstruction at the time of TORS with either pharyngoplasty or pedicled buccal adipose tissue and mucosal flaps as described above.

RESULTS

As with the much smaller procedure of tonsillectomy, patients experience some pain from days 2 through up to 2 weeks as the wound heals and granulates. Patients typically work with a speech pathologist for some basic swallowing exercises after 1 week, and the Dobhoff tube placed at the time of surgery is removed as early as day 4 but may need to remain for up to 2 weeks. The long-term risk for PEG dependence based on the cohort studies is 2.4%.

I typically stage the neck dissection 1 week to 10 days after the primary TORS resection for the cancer of the tonsil. The neck dissection can be performed at the same time; however, I prefer to have the final pathology results so that if a close margin is identified, then further resection at the primary site can be performed at the time of the neck dissection. Also, by staging the neck, I believe that there is a reduction in both the risk and extent of communication between the oropharynx and neck, which in theory reduces the risk of infection and fistula and postoperative edema of the pharynx. In the series by Moore et al., TORS was performed with a simultaneous neck dissection for oropharyngeal carcinomas, and they noted a high percentage of patients with resulting communication between the pharynx and the neck from the one-stage procedure (29%). When this type of communication occurred during radical tonsillectomy, 5 of 38 (13%) developed fistula postoperatively, despite the use of muscle flap reconstruction and primary closure. This is in comparison to no fistula reported in our series using staged neck dissection.

TORS is a safe and effective way of managing cancer of the tonsil provided that the key surgical steps and basic oncologic principles are adhered to. The use of minimally invasive surgery such as TORS may permit either elimination of or a de-escalation of adjuvant therapy, with lower doses and reduced volumes of radiation along with the potential for avoiding chemotherapy. This possibility is currently under prospective evaluation in clinical trials.

PEARLS

- Examination under anesthesia is critical for assessing mobility of the tumor and constrictor musculature over the prevertebral fascia in order to determine candidacy for TORS. Fixation of the cancer is considered a contraindication.
- Careful CT and MRI examination is critical for identifying the extent of cancer invasion into the base of the tongue and parapharyngeal space.
- The course of the internal carotid artery is noted so as to identify a retropharyngeal carotid artery, which is a contraindication for TORS.
- Identifying the medial pterygoid muscle superiorly after the pterygomandibular raphe incision is a key first step that provides orientation and leads one to the parapharyngeal pad of adipose tissue medially and then to the constrictors and confluence of the palatoglossus and palatopharyngeus muscles.
- Making an index incision on the medial margin of the pharynx and constrictors will help to reduce unnecessary dissection of constrictor musculature and excessive resection beyond needed margins, which may result in swallowing dysfunction acute or longer term.
- Identification of the lingual artery just above the hyoid bone and between the intrinsic muscles of the tongue and hyoglossus muscle lateral will allow for surgical clipping and reduction in the risk of postoperative bleeding.

PITFALLS

- Nasopharyngeal insufficiency with nasal regurgitation and rhinolalia may occur if extensive resection of the soft palate as far anterior as to the hard palate junction is required and no reconstruction with a local pharyngoplasty or buccal adipose tissue pad flap is performed.
- Extensive resection of the base of the tongue to the level of the contralateral lingual artery or through the hyoid in conjunction with the TORS radical tonsillectomy partial pharyngectomy procedure may lead to postoperative dysphagia, persistent swallowing problems, and possibly permanent reliance on G tube feeding.
- Failure to clip both the proximal lingual artery coming over the hyoid bone and the distal component extending anteriorly along the intrinsic muscles and extrinsic muscle planes will increase the risk of significant postoperative bleeding.

INSTRUMENTS TO HAVE AVAILABLE

- Intuitive da Vinci surgical robot (model S or Si)
- 5-mm instruments with Maryland grasper and spatula cautery attachments
- FK-WO mouth retractor with set of adjustable blades
- Mayo stand for suspension apparatus
- 30-degree angled endoscope
- 2-0 silk suture for tongue retraction
- Small Yankauer suction for smoke evacuation and retraction by assistant

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14 TRANSORAL LATERAL OROPHARYNGECTOMY (HUET'S PROCEDURE)

F. Christopher Holsinger

INTRODUCTION

The changing epidemiology of oropharyngeal cancer (OPC) has led to a greater role for transoral head and neck surgery within the multidisciplinary treatment paradigm. Reports from the United States and abroad have documented the precipitous rise in the incidence of OPC in individuals younger than typically expected for "traditional" patients with cancer of the head and neck. In a 2008 prospective case–control study, D'Souza and Gillison demonstrated an association between human papillomavirus (HPV) and OPC, as well as the role of increasing oral sexual partners. Using the Surveillance, Epidemiology, and End Results (SEER) repository, Chaturvedi reported in 2011 that the incidence of HPV-positive cancers of the oropharynx increased by 225% from 1988 to 2004. In addition, these HPV+ cancers usually present with a smaller size primary (T0-T2) than HPV-negative OPC, permitting effective transoral resection.

Fortunately, these cancers tend to respond favorably to standard organ preservation approaches. In RTOG 0129, Ang et al., highlighted the significant impact HPV status has on the treatment of OPC; after adjusting for demographics, T stage, N stage, and smoking, patients with HPV+ OPC had a 58% reduction in the risk of death and a 51% reduction in risk of progression or death. While these response rates are encouraging, young survivors of OPC have the potential to live decades with the sequelae of the treatment. Hutcheson et al., have recently drawn attention to the long-term chronic severe dysphagia and cranial neuropathies that may develop or progress years after radiation-based therapy for OPC.

Given the potential long-term sequelae of radiation in a rapidly enlarging population of young patients with OPC, transoral and endoscopic approaches to the tonsil and lateral oropharynx will play a greater role in the management of patients with OPC. With the development of surgical technology, including the surgical robot and laser techniques, the surgical procedure described here has more widespread application for transoral resection of cancers of the oropharynx.

The French head and neck surgeon Pierre-Charles Huet first described the transoral technique for resection of cancer of the lateral wall of the oropharynx, including the tonsil, tonsil fossa, and anterior tonsil pillar (ATP) (Fig. 14.1). In 2005, the first description of this surgical technique "transoral lateral oropharyngectomy" (TLO) was published in English and serves as the basis of subsequent robotic-assisted approaches. Huet's work demonstrated a safe approach to the parapharyngeal space (Fig. 14.2) to reduce substantially the risk of vascular injury while providing a comprehensive mucosal and deep muscular margin resection of the lateral wall of the oropharynx.

HISTORY

In addition to assessing the patient for the classical head and neck symptoms, such as dysphagia, weight loss, throat pain, oral bleeding, or mass in the neck, the head and neck surgeon should address several specific signs and symptoms for a candidate patient for TLO. These should include prior history of radiotherapy, dentition, cervical spine restriction on neck extension, and Mallampati classification.

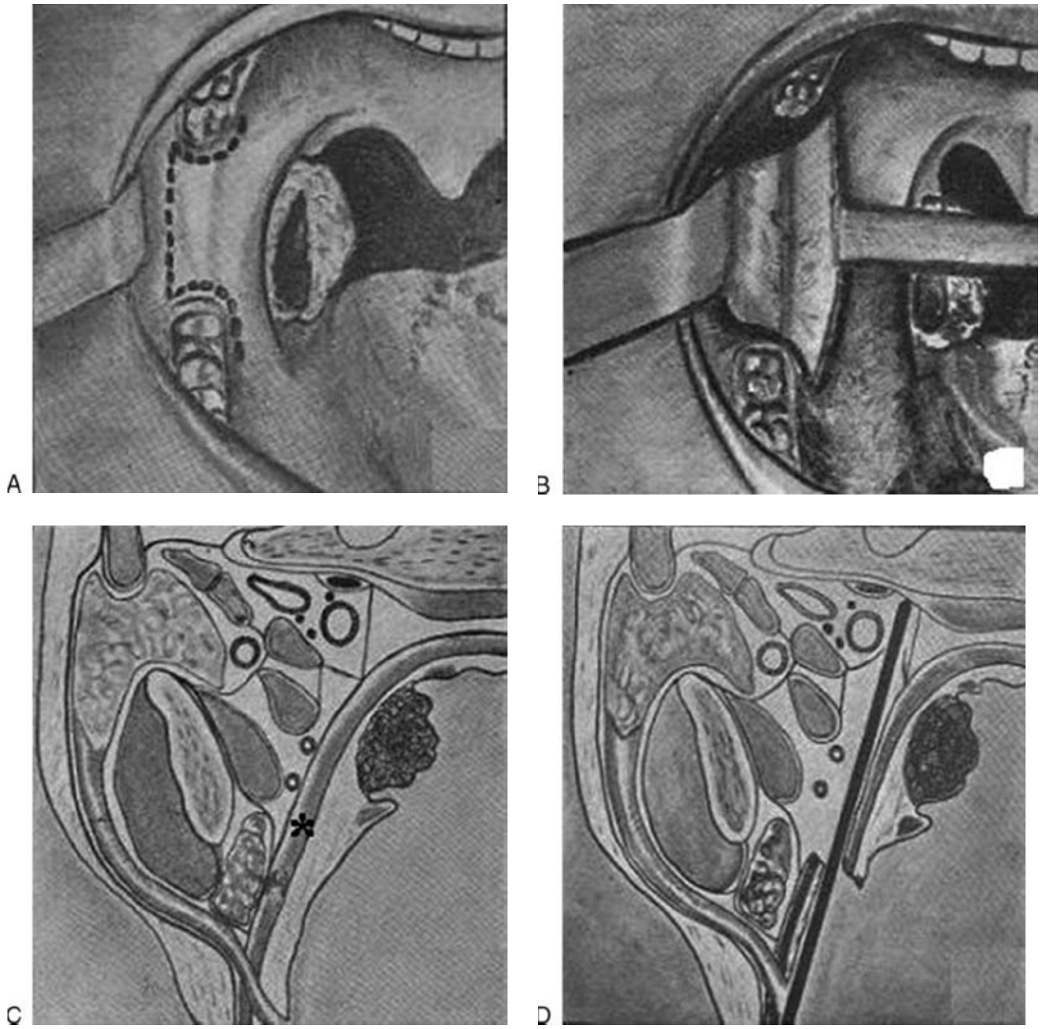

FIGURE 14.1
(Used with permission from Masson Editeurs [120, Bd. Saint-Germain, 75272 Paris Cedex 06, France]). **Panel A:** (**upper left**) demonstrates Huet proposed incisions. **Panel B:** (**upper right**) reveals the approach to the deep margin, opening the potential space between the medial pterygoid muscle and the superior constrictor, underlying the palatine tonsil. **Panel C:** (**lower left**) represents cross-sectional anatomy of the lateral oropharyngeal wall, with an asterisk inserted over the superior constrictor muscle. See Figure 14.2 below for further anatomic detail and higher resolution. **Panel D:** (**lower right**) demonstrates the proper cleavage plane to obtain complete mucosal and muscular resection of the lateral oropharyngeal wall.

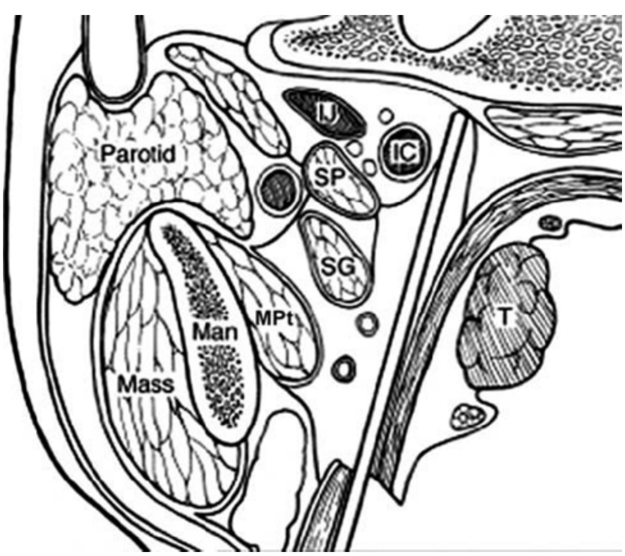

FIGURE 14.2
Safe approach to the deep retropharyngeal anatomy, after Huet. IJ, internal jugular vein; IC, internal carotid artery; Mass, masseter; Man, mandible; MPt, **m**edial **pt**erygoid muscle; T, tonsil; SG, styloglossus muscle; SP, stylopharyngeus muscle; Parotid, parotid gland.

PHYSICAL EXAMINATION

As always, a complete head and neck examination should be performed preoperatively. Visual inspection and careful palpation of the ipsilateral tonsillar fossa is important to properly select patients for this surgery. The surgeon should confirm that the tumor is "mobile." That is, compared to the uninvolved contralateral tonsil, the tumor should roll and pivot as the lateral wall of the oropharynx is carefully palpated. If the tonsil is adherent to the underlying superior constrictor muscle, digital manipulation will reveal this. Fixation of the tonsil to the deep planes of the wall of the oropharynx is a contraindication to surgery.

The boundaries of the tonsil fossa must be carefully examined. Tumors that involve the ATP may extend onto the mobile tongue and floor of mouth. These cancers of the ATP may even extend superficially past the retromolar trigone and toward the buccal mucosa so these areas should be inspected with a bright light and be palpated. The posterior tonsil pillar should also be carefully examined. Tumors that have extensive involvement of the posterior tonsil pillar have a higher rate of local recurrence after Huet procedure and may also have a primary nodal echelon that drains to the retropharynx. Tumors in this site are probably better treated with radiation therapy.

The surgeon should also carefully evaluate the remainder of the patient's base of the tongue and contralateral tonsil, for sites of synchronous "second" primary cancers, especially in the case of smokers. Synchronous contralateral tonsil cancers are exceedingly rare, but other cancers or premalignant foci in the oral cavity or base of the tongue can sometimes be found. I always measure the extent of spread vertically, to the soft palate above, and inferiorly below to the supraglottic larynx. For instance, when the inferior pole of the tonsil is involved, I always carefully discern the relationship of this cancer to the pharyngoepiglottic fold below and look for potential "cascading" extension into the base of the pyriform sinus, the gateway to the hypopharynx.

Finally, it is important to measure and document interincisor opening, allowing the surgeon to estimate how easy transoral access will be for the surgical resection. I also use the Mallampati scale to estimate the difficulty of exposure. In general, the higher the Mallampati score, the more difficult it is to gain exposure in the operating room.

I always perform an ipsilateral neck dissection of levels II–IV. This can be staged or done concurrently. I do not frequently dissect level I-b, as this nodal echelon is more commonly involved in oral cavity, rather than OPCs. However, I will always fully skeletonize and resect lymphoadipose tissue along the posterior facial vein, which forms the lateral border of I-b, and its path toward the internal jugular vein. As part of the neck dissection of levels II–IV, I'll usually include some of the anterior most aspect of level Vb—those nodes imbricated within the cervical plexus, which I routinely spare.

Though many tumors are resectable via transoral surgery, I tend to operate on patients with limited neck disease, typically N0-2a and occasionally N2b. Patients with N3 neck disease are better served generally with upfront induction chemotherapy, followed by risk-based locoregional therapy, depending on response.

Many head and neck oncologists are rightfully concerned about the retropharyngeal lymphatics in patients with tonsillar carcinoma. In general, patients with posteriorly based tumors, especially toward the posterior oropharyngeal wall or posterior tonsil pillar, are at highest risk for retropharyngeal metastasis. I tend not to operate on these patients. Occasionally though, I will encounter nodes just superficial to the parapharyngeal adipose tissue. With experience, these can be safely removed via transoral exposure.

INDICATIONS

- T1-T2 cancers of the lateral wall of the oropharynx, including the tonsil fossa and ATP
- Selected T3 lesions, especially exophytic cancers, may also be amenable to transoral resection.

CONTRAINDICATIONS

- Patients with trismus, which suggests involvement of the medial pterygoid muscle
- Patients with significant involvement of the parapharyngeal adipose tissue or extension toward the internal carotid artery (ICA)
- Patients with ectatic ventrodorsally placed internal carotid arteries, Paulsen type C "kinking" with S-or C-shaped elongations, and tortuosities
- Extensive palatal involvement requiring obturation and tonsillar fossa/tongue base resection
- Patients with T4 tonsillar carcinomas

SURGICAL TECHNIQUE

Huet Procedure Versus Simple or Radical Tonsillectomy

Huet procedure is a true lateral oropharyngectomy and should be distinguished from the standard "diagnostic" tonsillectomy. Therefore, its clinical value and use must be distinguished from the more common procedure.

For patients with an "unknown" primary cancer, I generally proceed with a standard "diagnostic" tonsillectomy, with a narrow mucosal margin without resecting the underlying superior pharyngeal constrictor muscle.

However, if preoperative imaging is strongly suggestive that I might find the primary cancer during standard tonsillectomy, I would get the patient's consent for possible complete resection depending on intraoperative findings and as indicated convert the procedure into a more formal lateral oropharyngectomy.

In general, for the "unknown" primary cancer, I'll perform bilateral diagnostic tonsillectomy. However, I would not ever plan or perform simultaneous bilateral Huet procedures.

Exposure

TLO is performed with the patient in the supine position, under general anesthesia. I prefer a contralateral nasopharyngeal intubation when the cancer is confined to the tonsil or glossopharyngeal sulcus. If the cancer is located more superiorly in the ATP or near the soft palate, I use a standard oral intubation.

An oropharyngeal retractor is used to provide transoral surgical access. For cancers of the tonsil and soft palate, a Crowe-Davis or Dingman retractor is preferred. For a cancer of the tonsil with any spread to the glossopharyngeal sulcus or the base of the tongue, I recommend using the Feyh-Kastenbauer oropharyngeal retractor. This system permits the use of blades of differing length, width, and shape to retract and move the tongue without removing the retractor system.

In the past, I performed this procedure using simple electrocautery, surgical loupes, and a headlight. The needle tip attachment can be used to make the initial mucosal incisions to minimize thermal trauma to palatal, buccal, and floor or mouth margins, but in general the spatula tip is used through the rest of the procedure. I prefer a protected shaft and Teflon spatula, when possible. I now routinely incorporate a surgical robotics system to provide better visualization, dexterity, and precision when operating on the lateral oropharynx. The transoral robotic procedure though is essentially that described here and initially published by Huet in 1951.

Incisions

Margins can easily be underestimated in transoral surgery. For this reason, I mark a 10-mm boundary around the entirety of the cancer before the superficial mucosal incisions are made. I create a measuring stick by cutting a paper ruler down to size, measuring exactly 10 to 15 mm, and then mount this onto gently curved forceps. The mucosa of the palate, oral cavity, tonsil, and tongue base is then dried with surgical gauze. Once dry, I use this customized surgical marker to define medial, lateral, superior/cranial, and inferior/caudal margins. Finally, before I incise the mucosa, I take into account the location of the cancer. If the cancer arises superiorly within the fossa or along the ATP, I initially begin to develop the surgical specimen superiorly. Below, the procedure is described from cephalad to caudal, but the procedure should be tailored to the individual patient based on the location of cancer and the extent of its spread. For instance, to approach a cancer located inferiorly, the superior aspect of the resection is completed first and vice versa. This provides the surgeon with tissue substantial enough to grasp and provide adequate traction–countertraction within the surgical field.

From superior to inferior, the mucosal incisions should curve laterally along the lateral soft palate and then out over the retromolar trigone and sometimes even into the buccal mucosa, especially for lesions of the anterior tonsillar pillar. The absence of muscular landmarks may permit the submucosal spread of cancer of the oropharynx into the oral cavity here and also into the floor of mouth. Keep this in mind when designing the initial incisions. In general, the incision is extended superiorly along the maxillary dentition and inferiorly at the level of the extreme posterior floor of the mouth (Fig. 14.3).

Resection

The submucosal raphé between the superior constrictor and buccinator muscles is then identified. The cancer and released adjacent lateral wall of the oropharynx and tonsil are then grasped with a tenaculum and drawn medially allowing the superior constrictor muscle to be visualized deep to the tonsil fossa (Fig. 14.4). When there is adequate medial retraction, this maneuver opens the submuscular plane deep to the superior constrictor muscle, which forms the deep boundary of the lateral wall of the oropharynx. As the specimen is grasped and drawn medially, the medial pterygoid muscle is then seen adherent to the lingual aspect of the mandible. Identifying the pterygoid allows the surgeon to dissect safely more deeply toward the parapharyngeal adipose tissue just below, which has been exposed by good medial retraction.

Once the lateral wall of the oropharynx has been opened, the wound is linear and does not allow the surgeon to see the full depth of the wound. So, the surgeon must release from above and below, creating a straight linear wound into a curved "C-shaped" defect.

Superiorly, the soft palate and ATP are divided, based on the extent of the cancer and the desired margins of resection. I then release the medial most palatal mucosa and then descend while dividing the posterior tonsil pillar onto the posterior pharyngeal wall. At this point, I usually mark the medial margin onto the posterior

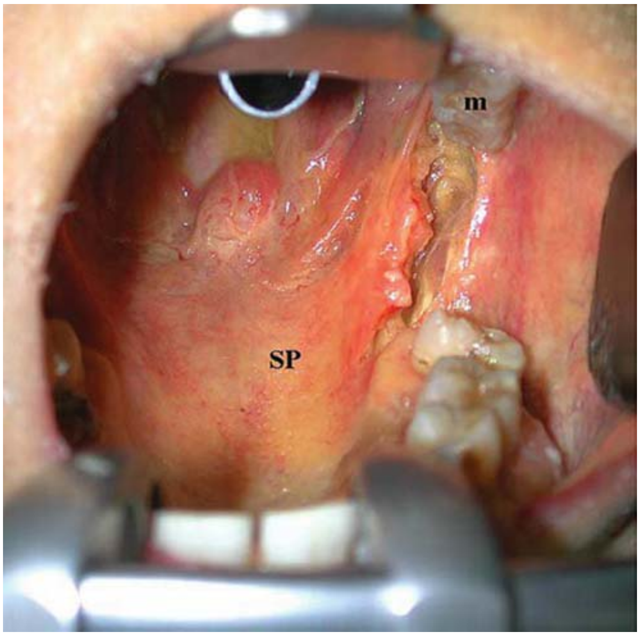

FIGURE 14.3 Incisions and identification of landmarks. The region between the maxilla and mandible is palpated, and the raphé between the superior constrictor muscle and the right buccinator is divided. m, mandibular dentition; SP, soft palate.

wall of the oropharynx with superficial scoring mucosal incisions, which conserves mucosal while optimizing margins of resection.

Inferiorly, the specimen is divided, depending on the extent of cancer, below the insertion of the ATP onto the base of the tongue. If needed, I will also curve the incision into the posterior floor of mouth, especially if the cancer is creeping along the ATP itself. Here, a resection of the glossopharyngeal sulcus and resection of the base of the tongue will be performed. Once released laterally and above and below, the entire specimen can be mobilized and the depths of the wound at the parapharyngeal space can be safely explored.

The stylopharyngeus and styloglossus muscles are identified and transected. Often branches of the glossopharyngeal nerve are seen between these muscles (Fig. 14.5). Here branches of the ascending pharyngeal artery, the tonsil branch from the facial artery, and the dorsal lingual branch of the lingual artery can be encountered. I prefer to clip these vessels, rather than to use bipolar cautery. I use the LT200 LIGACLIP (Ethicon, J&J, Cincinnati, OH) and LARYNGOFORCE clip appliers (Karl Storz 8665L and 8665R), which are critical for managing these vessels. While bipolar cautery works well during surgery and within the immediate postoperative period, I suspect that these vessels are at risk for delayed rupture when exposed to the harsh pharyngeal environment of saliva and enzymes when the wound is left to heal by secondary intention.

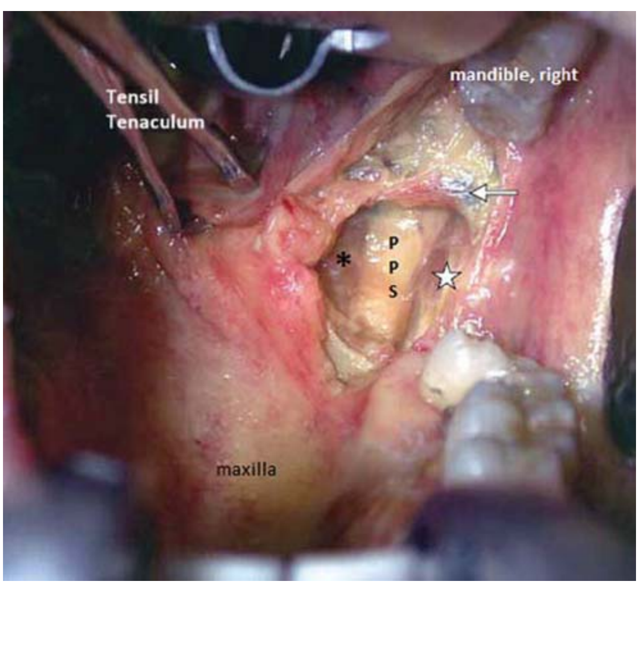

FIGURE 14.4 A submuscular plane of dissection is developed as the ipsilateral tonsil is gently grasped with a tonsil tenaculum and drawn medially. For orientation, the right mandible is identified above, the maxilla below. *Asterisk*, under surface of superior pharyngeal constrictor muscle; *white star*, right medial pterygoid muscle; *white arrow*, vein deep to the constrictor muscle, requiring vascular clip for hemostasis; PPS, parapharyngeal space adipose tissue.

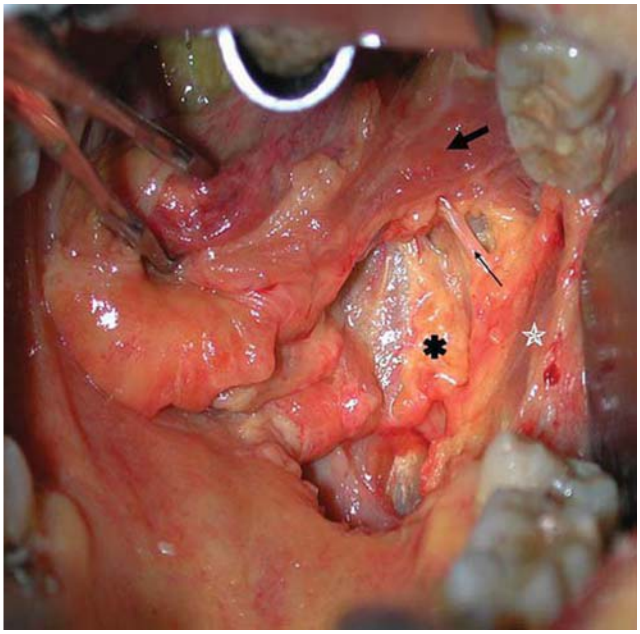

FIGURE 14.5
Styloglossus muscle (*short, bolded arrow*) is shown before transaction. A branch of the glossopharyngeal nerve is also seen (*dark thin arrow*). For further orientation, the right medial pterygoid muscle is indicated by a *white star* and lobules of adipose tissue covering the ICA indicated by *black asterisk*.

Finally, I connect the superior incision made in the posterior pharyngeal wall to the inferior margin of the resection. I usually leave the surgical wound to heal by secondary intention. A skin graft or AlloDerm graft is never used. Occasionally, if this procedure is performed as surgical salvage, I'll use a free flap or local buccal flap to cover the vessels.

Margin Assessment

Ideally, I include margins from the following quadrants: medial, lateral, anterior, superior, and deep. Prior to making incisions, I draw out 1-cm gross visual mucosal margin, aiming to achieve ultimately a minimum of 3-mm microscopic margins. I tend to perform this resection en bloc, though Steiner and others have advocated for a more tailored approach.

Huet procedure can be performed, either before or after the neck dissection. For the less experienced surgeon, it can be reassuring to perform the neck dissection prior to TLO. This allows the surgeon to locate, ligate, and control branches of the external carotid system, as well as to protect the ICA. However, there may a slightly increased risk for postoperative fistula when the neck dissection is performed concurrently. Moore reviewed the Mayo experience of 148 consecutive transoral resections with concurrent neck dissection and found that 42 (29%) patients had some form of an orocervical communication intraoperatively. All were managed with some combination of primary closure, local tissue advancement, application of fibrin glue, and placement of a suction drain. Only, six (4%) developed a subcutaneous pharyngeal fluid accumulation requiring postoperative management. However, no patients experienced a delay from their operative treatment that prevented them from initiating recommended adjuvant radiation therapy on schedule. The Mayo group subsequentially demonstrated a reduced rate of orocervical communication when the thulium:YAG laser was used for mucosal incisions and dissection, though in a smaller cohort of patients.

POSTOPERATIVE MANAGEMENT

Following Huet procedure, most patients can be managed with a brief inpatient hospitalization, usually 2 to 3 days. I routinely treat patients with broad-spectrum antibiotics for 5 days, antireflux therapy (usually a proton pump inhibitor) for 1 week, and analgesics for postoperative pain. Steroids are not used postoperatively. Postoperative recovery is facilitated with careful oral care and frequent salt and soda rinses, three times a day, as well as before and after meals.

Swallowing and airway concerns dominate the immediate postoperative management.

Swallowing

Depending on the extent of resection, oral alimentation is begun, on postoperative day 1, even if a nasogastric tube has been placed. Patients should ideally be seen by a speech language pathologist the day of or following surgery. The consistency of the diet should begin with a soft, mechanical, or pureed diet. Immediately

following surgery, the patient should be counseled regarding nasopharyngeal reflux due to velopalatal and velopharyngeal insufficiency. If the resected cancer arose along the ATP or tonsil fossa and definitely in the soft palate, patients will experience nasopharyngeal reflux lasting from several days to as long as 2 to 3 weeks. I always mention this possibility preoperatively and this discussion is an important part of the informed consent process. When drinking liquids quickly, patients should exercise the greatest caution and avoid elevating the head.

If TLO is performed as surgical salvage following previous radiation (RT) and/or concurrent chemoradiation (cRT), resumption of oral diet is usually delayed due to poor sensation and prolonged wound healing. Especially after previous RT or cRT, submucosal spread of disease for inferiorly or superiorly can be encountered, unexpectedly enlarging the size of the mucosal defect. Often, I offer these patients preoperative elective placement of a percutaneous endoscopic gastrostomy tube.

Airway

Tracheostomy is not routinely required following TLO, but I always discuss this possibility as well preoperatively.

COMPLICATIONS

In the University of Paris experience, postoperative surgical complications after the Huet procedure were low. Overall, 6.3% of patients developed a complication from the surgery of the oropharynx. The most common complication was not bleeding or dysphagia but nasopharyngeal reflux and severe rhinolalia, which occurred in nine patients (4.7%).

RESULTS

Reviews from several institutions now demonstrate that for properly selected cancer of the tonsil, Huet procedure provides local control comparable to radiotherapy.

In a review of 166 patients, from the University of Paris, 1- and 5-year Kaplan-Meier local control estimates were 98.3% and 89.0% for T1 and 88.9% and 81.7% for T2 but declined for patients with larger T3 tumors 78.9% and 62.7% for T3 lesions, respectively. Spread to the posterior pillar was associated with higher rates of local failure.

Moore et al., reviewed the Mayo experience in 2009 with 102 patients having transoral surgery for cancer of the tonsil and found similar results. Kaplan-Meier overall survival estimate was 92.2% at 2 years and 85.0% at 5 years. The 5-year local control estimate was 91.8%, and the 5-year Kaplan-Meier disease-specific survival estimate was 93.9%. In contrast to patients receiving primary radiation, only 16 patients needed a gastrostomy tube during treatment, only 4% needing them past 4 years.

In summary, patients with T1 - T2 squamous cell carcinoma of the tonsil, without spread to the posterior pillar had a high rate of local control as well as good functional outcomes, using Huet transoral approach.

PEARLS

- Palpate the tonsil to ensure mobility. A wooden tongue depressor provides an inexpensive and useful adjunct to digital examination.
- Understand that this is a mucosal and muscular resection of the lateral oropharynx, not simply a "radical" tonsillectomy. This old term is inaccurate and should be avoided. The deep margin at the parapharyngeal adipose tissue is the superior constrictor muscle.
- Use surgical clips on all branches of the external carotid system (ascending pharyngeal artery, tonsil branch of the facial artery, dorsal lingual branch of the lingual artery).
- Discuss with the patient preoperatively the need for short-term nasogastric feeding.

PITFALLS

- Do not perform this surgery on patients who have trismus or limited interincisor opening.
- Study preoperative imaging CT or MR carefully
  - To ensure that the cancer does not encroach upon the parapharyngeal adipose tissue
  - To identify medial variants of the ICA, with kinking >90 degrees
  - And/or proximity to the constrictor muscle
- Do not reconstruct this defect with a skin graft or AlloDerm, as sloughing will occur postoperatively, potentially creating airway and/or wound care issue.

INSTRUMENTS TO HAVE AVAILABLE

- Monopolar electrocautery tip
- Angled bipolar electrocautery forceps
- Tonsil tenaculum
- Toothed grasping forceps (Cushing)
- da Vinci Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA)
- Zero-degree 8.5- or 12-mm stereo endoscope
- 5-mm Maryland grasping forceps
- 8-mm Cadiere grasping forceps
- 5-mm spatulated monocautery tip

SUGGESTED READING

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15 MARGINAL MANDIBULECTOMY

Christopher H. Rassekh

INTRODUCTION

Marginal mandibulectomy can be defined as any removal of a portion of the mandible that does not result in a segmental defect. Marginal or nonsegmental mandibulectomy can be divided into three basic types (Table 15.1): (1) inner table mandibulectomy (intraoral), (2) alveolar ridge or superior rim mandibulectomy (intraoral), and (3) outer table mandibulectomy (extraoral). Outer table mandibulectomy is occasionally performed, mainly for tumors that adhere to the periosteum of the outer cortex. For example, skin cancers, cancers of the lower lip, inferior buccal sulcus cancers, or lymph nodes in the region of the facial artery may be adherent to the lateral mandibular periosteum. These are best managed by resection of the outer table of the mandible and preservation of the inner table. The technical principles are the same, so this chapter focuses on the intraoral techniques.

Inner table mandibulectomy can be performed on the anterior or lateral mandibular region for cancer of the floor of mouth, retromolar trigone, or gingiva. When cancers of the gingiva are isolated to the alveolar ridge and/or buccal mucosa, marginal mandibulectomy may spare some of the inner table. Often, inner table mandibulectomy and alveolar ridge mandibulectomy are combined, preserving an adequate strut of outer table to prevent fracture. In general, preserving 11 mm of vertical height is the minimal strut to minimize the risk of fracture. This is not a hard and fast rule because the length of the defect likely contributes to any instability as well. In some patients, the stability of the remaining bone may be reinforced with a titanium plate.

HISTORY

When evaluating a patient for possible marginal mandibulectomy, it is important to determine other aspects of the patient's cancer and comorbidity and to be informed of any prior therapy, especially any prior radiotherapy or surgery, including dental procedures. In addition, any history of trauma to the mandible or surrounding region should be sought. It is also important to assess the patient's specific needs with regard to dental rehabilitation and mastication.

PHYSICAL EXAMINATION

Preoperative assessment of the extent of tumor involvement is critical. Physical examination remains the most reliable predictor of the extent of mandibular involvement, and various radiographic techniques can be used as an adjunct and may upstage some patients. Often irregular bone can be palpated in the crater of an ulcerated cancer. Palpation of the tumor may require examination under anesthesia due to pain. The dimension and location of the tumor should be recorded for staging purposes.

TABLE 15.1 Types of Marginal Mandibulectomy (Nonsegmental Mandibulectomy)
Inner table mandibulectomy
Alveolar ridge mandibulectomy
Combined inner table and alveolar ridge mandibulectomy
Outer table mandibulectomy

INDICATIONS

Indications for marginal mandibulectomy are discussed in the Introduction and are summarized in Table 15.2.

CONTRAINDICATIONS

Marginal mandibulectomy should not be performed in patients who have through and through destructive lesions of the mandible or in those patients who have gross invasion of the marrow of the mandible by tumor and is generally reserved for patients who are suspected by clinical or radiographic examination of having periosteal invasion or limited invasion of cortical or alveolar ridge bone. Patients who have lesions in the lateral mandible and who have had prior radiotherapy are less suitable candidates for nonsegmental resections (Table 15.3).

PREOPERATIVE PLANNING

Patients should be counseled that if the tumor is adherent to the bone, but if they are then found at surgery to have evidence of invasion, a more extensive (segmental) mandibular resection may be required. Reconstruction for segmental defects is more complex, and this requires careful counseling. In some cases, such a procedure may be staged.

CT, MRI, plane films, bone scan, and dentascan may all play a role depending on the situation. Perhaps the most useful imaging study is the bone window of a fine-cut CT scan to assess integrity of the cortex in multiplanar fashion. T1-weighted and T2-weighted and short T1-inverted recovery MRI are often useful to rule out marrow invasion. One should be cautious about reactive bone changes that may be seen on imaging and rely on clinical examination when there is a discrepancy until proven otherwise to avoid an unnecessary segmental resection.

SURGICAL TECHNIQUE

Marginal mandibulectomy is a highly effective procedure in the proper setting. Nonsurgical management of such lesions is suboptimal in terms of both local control and morbidity because radiotherapy is a less effective oncologic treatment for these lesions. Even when it controls the cancer, the entire mandible is compromised by radiotherapy and may eventually be destroyed by osteoradionecrosis.

Marginal mandibulectomy requires general anesthesia with nasotracheal intubation or tracheostomy. For more extensive procedures, tracheostomy is mandatory. It is important to be aware that sometimes the extent of soft tissue involvement is greater than that of the bone removal. It is usually possible to remove a larger area of periosteum than of mandible in these resections to be sure of adequate periosteal margins. Of course,

TABLE 15.2 Indications for Marginal Mandibulectomy
Cancer of the lower lip
Cancer of the oral cavity—floor of mouth, retromolar triangle, gingiva, buccal mucosa
Cancer of the oropharynx involving the posterior mandible
Metastasis to cervical lymph nodes
Skin cancer

TABLE 15.3 Contraindications to Marginal Mandibulectomy
Gross invasion of the bone marrow
Invasion of the inner and outer cortex of mandible
Involvement of the lateral mandible following radiotherapy

mucosal, submucosal, muscle, and other soft tissue margins should be managed as they are for the particular type of cancer present. While outside the scope of this chapter, marginal mandibulectomy is often combined with resections of cancer of the oral cavity, dental extractions, and neck dissection at the same sitting. Posterior mandibular resections are technically more difficult as would be expected.

While also beyond the scope of this chapter, resections that include a marginal mandibulectomy will often require a reconstructive procedure beyond simple primary closure because primary closure will often tether the soft tissues and thereby compromise oral cavity function (tongue mobility and denture fitting are key issues here). Skin grafts, local flaps, pedicled flaps, and free fasciocutaneous flaps are all options depending on the soft tissue and bone component of such defects.

The mucosal margins are assessed and index cuts are made where feasible (Fig. 15.1). Ideally, the entire soft tissue component of the tumor is released from the underlying deep margin of resection and the tumor pedicled on the area in question (Video 15.1). While the periosteum may be elevated and the soft tissue component of the tumor removed separately, my preference is to leave the tumor attached to the bone if it is possible, to facilitate pathologic orientation of the specimen. In general, 1.5 to 2.0 cm of normal bone should be included at the peripheral margins of resection. Typically, the alveolar ridge is resected down to the tooth roots, and care is taken to preserve the mental and lingual nerve when cancer invasion does not preclude it. Vertical osteotomies are made in the aspect of the tooth socket closest to the cancer in order to preserve as much as possible bone around the residual tooth. Care is taken not to remove too much of the vertical dimension of the mandible so that the remnant will be stable. If the patient is dentulous, the tooth on either side of the fragment to be removed is extracted (Fig. 15.2A). The alveolar ridge osteotomies are made in the extraction sites. This can be done with either a reciprocating or an oscillating saw. My preference is the reciprocating saw with a wedge-shaped blade. Then an oscillating blade is used to make an osteotomy from the anterior outer cortex (buccal surface) through the inner (lingual) cortex (Fig. 15.2B). Osteotomy is illustrated being performed on a lateral lesion (Fig. 15.2C and D). Soft tissue (margin) incisions should be made with a fine scissor or a no. 15 blade for precision. The bone fragment and soft tissue including the cancer are removed en bloc. In selected cases, the incision may be extended in a sagittal plane to include the entire lingual table of the mandible if desired. This preserves the inferior half of the buccal cortex. For buccal cortex mandibulectomy, the reverse is performed usually from the neck, and in selected cases, the alveolar ridge may be preserved if it is free of tumor. If sharp bone edges remain after resection, they are polished with a cutting and/or diamond burr to create a more curvilinear saucerized appearance to the defect.

The cheek flap approach may be used for a lateral lesion (Fig. 15.3A and B). Bleeding can be controlled with topical agents such as oxymetazoline-soaked cottonoids. If the remaining mandible is felt to be prone to

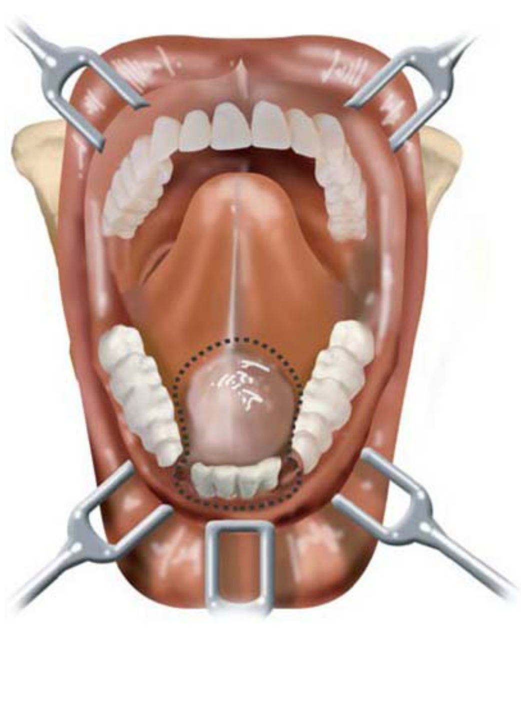

FIGURE 15.1 Drawing of mucosal incisions.

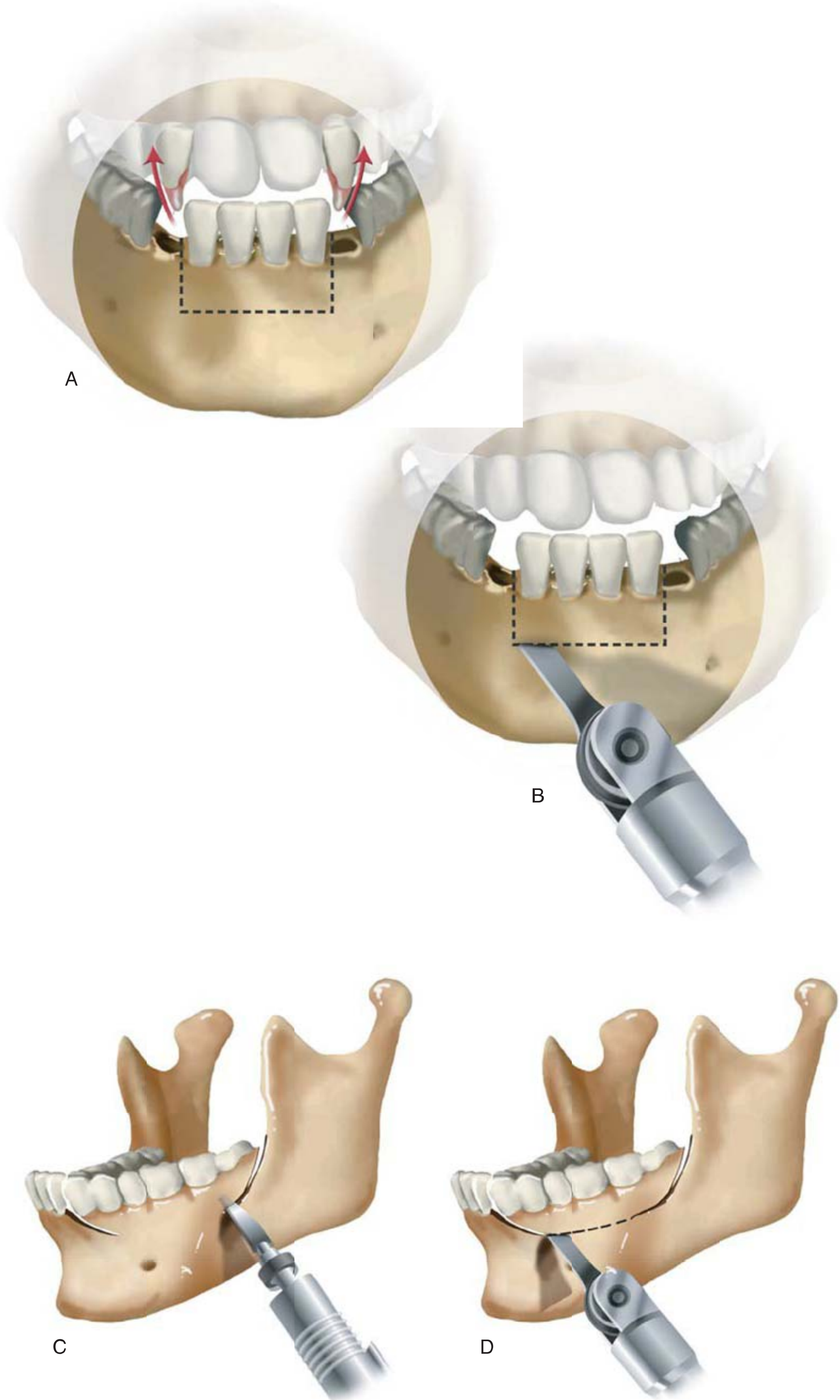

FIGURE 15.2
A: Diagram of dental extractions and osteotomies for anterior lesions.
B: Osteotomies are made in the extraction sites;
C,D: Diagrams of osteotomies for lateral lesions.

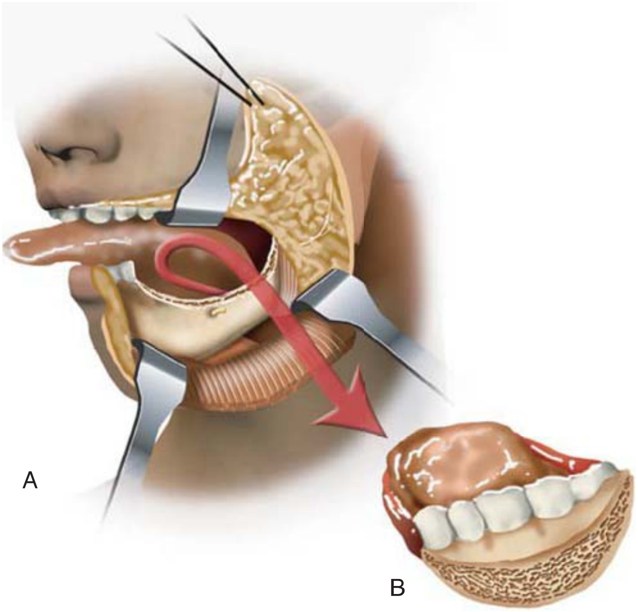

FIGURE 15.3 A: Drawing of cheek flap approach and lateral marginal mandibulectomy; **B:** Specimen of bone and soft tissue removed en bloc.

fracture, reinforcement using a plate is advisable (Fig. 15.4). In general, vertical height <11 mm is the criterion for a plate. Reconstruction is then performed as necessary using either a skin graft (Fig. 15.5) or a free flap.

POSTOPERATIVE MANAGEMENT

In cases with limited resections and small skin grafts, the endotracheal tube may be removed. The postoperative management is generally associated with the extent of resection, the type of reconstruction, and the need for tracheostomy and not by the mandibulectomy. Length of stay also varies accordingly.

COMPLICATIONS

Fracture is the most common complication and prevention is paramount. Potential or actual fracture is managed like any other mandible fracture with hardware (Fig. 15.4). Another complication is failure to recognize more extensive mandibular involvement (in other words, poor patient selection), which should warrant segmental mandibulectomy.

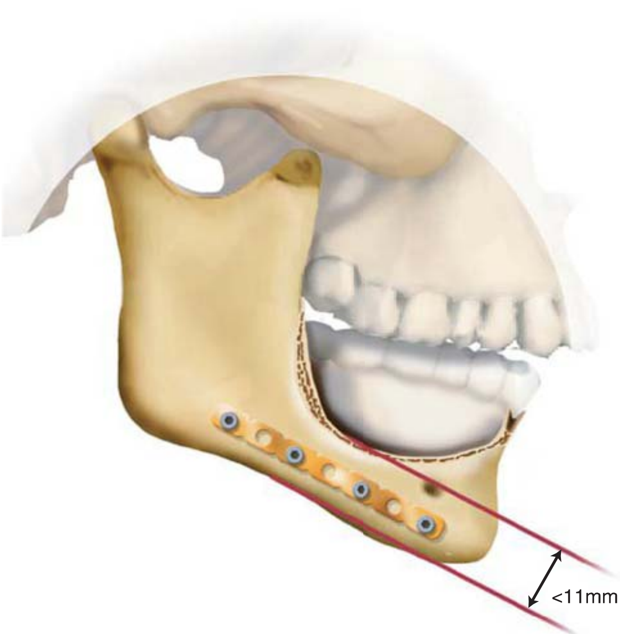

FIGURE 15.4 Titanium plate reinforcement used for remnant of bone <11 mm in height.

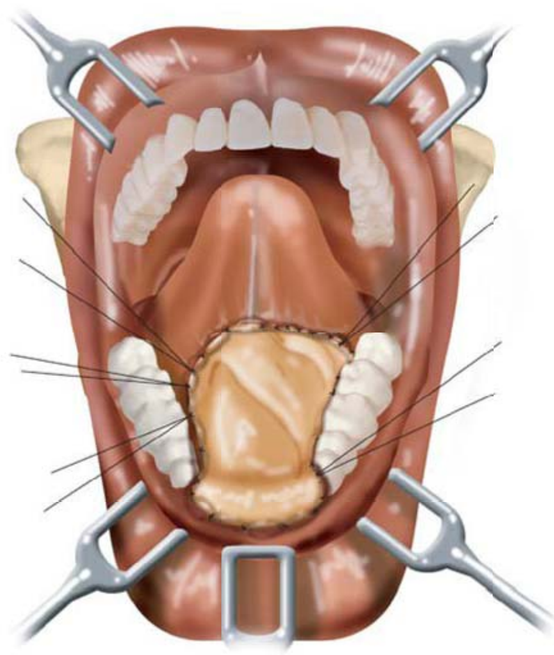

FIGURE 15.5
Reconstruction of defect using a split-thickness skin graft.

RESULTS

The oncologic and functional outcome of properly selected and properly performed marginal mandibulectomy is usually excellent. Radiation should rarely be required postoperatively as negative margins should be the rule. However, some patients will require radiotherapy for more advanced lymph node metastasis or perineural invasion.

PEARLS

- Choose marginal mandibulectomy for posterior oral cavity tumors, or those in dentulous patients, to ensure sufficient bone stock and height to reduce fracture risk of remnant inferior bone stock.
- An oscillating saw or a small otologic drill bit can be used for the osteotomy, depending on the height of the bone stock.
- Use local mucosal tissue, pedicled or microvascular flaps, instead of a skin graft to resurface the bone defect and to avoid bone exposure.

PITFALLS

- Avoid mental nerve, which provides sensation.
- Avoid sharp angles, which can protrude through the reconstruction or mucosa.
- Avoid leaving <11 mm of bone in the remaining cortex or use plate to reinforce, in order to reduce fracture risk.

INSTRUMENTS TO HAVE AVAILABLE

- Head and neck soft tissue tray
- Cautery
- Dental extraction set
- Cottonoids with Afrin
- Saw with both wedge-shaped reciprocating saw and oscillating blade
- Drill for smoothing the contour of the bone

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16 LATERAL SEGMENTAL MANDIBULECTOMY

Mark K. Wax

INTRODUCTION

The mandible plays a fundamental role in the form and function of the lower face and upper aerodigestive track. Mastication, speech, deglutition, and protection of the airway are all dependent on a normal, functioning, and intact mandible. Primary tumors of the mandible are rare. The most common malignant tumor to involve the mandible is squamous cell carcinoma arising from the oral cavity or oral pharynx. Rarely the mandible may be affected by cancer of the skin that has grown through soft tissues to invade the mandible or from direct invasion through a metastatic lymph node. These situations are usually related to neglected or previously treated cancer (Fig. 16.1).

When the mandible is involved by cancer, treatment needs to involve resection and usually immediate reconstruction. In processes that involve the mandible primarily, whether they be osteoradionecrosis, primary tumors of dental or alveolar origin, or, rarely, metastatic cancer, a tissue diagnosis must be obtained, which usually involves open biopsy. More commonly, the mandible is involved through direct invasion from a contiguous structure and biopsy of that structure demonstrates the histopathology. The questions then are: (1) Is the mandible involved and (2) can less than a segmental resection of the mandible be performed?

HISTORY

Malignant tumors arising in the oral cavity or oral pharynx that are adjacent to or fixed to the mandible require assessment for mandibular involvement. It is beyond the scope of this chapter to discuss presentation of and the history of tumors rising in the oral cavity or oral pharynx. It is well known that the mandible or periosteum is felt to be resistant to tumor invasion. This resistance disappears in a variety of circumstances. Patients who have had prior radiotherapy, surgical procedures that involve periosteal stripping or resection, or structures close to the periosteum, such as teeth, are more prone to demonstrate invasion of the mandible than those who have not received previous treatment or are distant from the periosteum. Anteriorly, the genioglossus muscle attaches directly into the genioglossal tubercle. Invasion of a primary cancer of the tongue or floor of mouth can track along these muscular processes and invade the mandible (Fig. 16.2). Finally, another route of invasion into the mandible is through invasion of the inferior alveolar nerve/mental nerve. Cancers that have neuropathic tendencies may invade the inferior alveolar nerve through the mental foramen with subsequent invasion of the mandible.

A history of numbness of the lip may indicate that one should look for invasion of the mandible by a neuropathic tumor. If the patient has teeth, then loosening of the teeth or sudden loss of teeth suggests that the patient has invasion of the mandible.

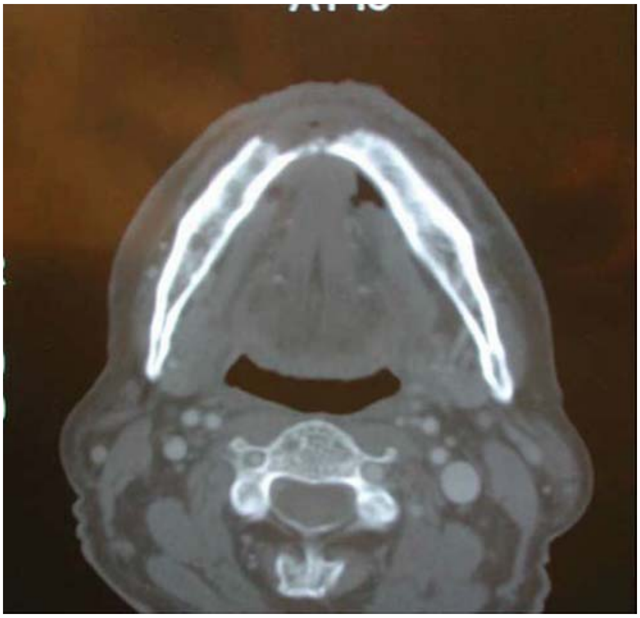

FIGURE 16.1
This patient has let a squamous cell carcinoma of the skin of the chin advance to the stage where it has invaded into the bone of the anterior mandible.

PHYSICAL EXAMINATION

All lesions of the oral cavity or oral pharynx require thorough inspection and bimanual palpation. Most of the lesions will show separation of the primary tumor from the mandible. When assessing cancers in the retromolar trigone, one oftentimes can see tumor extension over the angle or ramus of the mandible. The tumor may be fixed to the mandible at this location because the mucosa and periosteum are very thin. Examination of the teeth and the alveolar ridge will also help determine if there is an adequate soft tissue margin or if there is, in fact, invasion of the mandible (Table 16.1).

In patients who have been previously treated with radiotherapy or neck dissection and are presenting with a recurrent mass in the neck that is either close to or appears to be fixed to the lateral border of the mandible, an examination with bimanual palpation to demonstrate normal tissue planes or fixation of the mass to the mandible is essential.

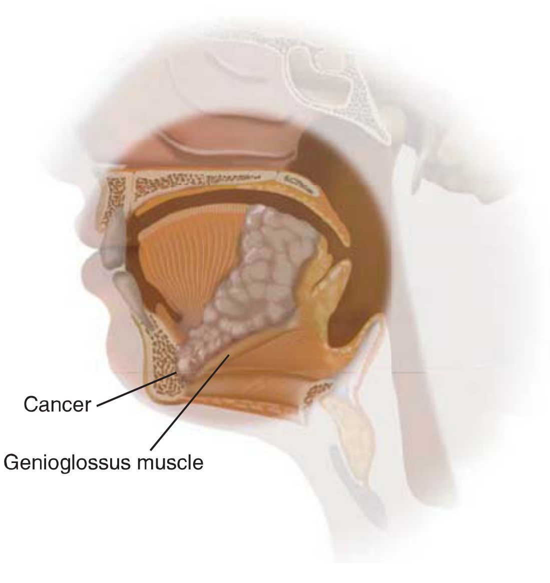

FIGURE 16.2
This artist rendition demonstrates how a cancer can invade along the muscular attachment into the genioglossal tubercle and thus invade the anterior mandible.

TABLE 16.1 Factors Contributing to Invasion of the Mandible
Edentulous patient
Extensive neglected tumor
Presence of osteoradionecrosis
Previous mandible surgery
Previous radiation therapy

PREOPERATIVE PLANNING

Imaging Studies

Imaging studies are essential in the evaluation and in planning reconstruction for patients who are going to undergo lateral segmental mandibulectomy. Evaluation to assess if there is invasion of the mandible and then the extent of the invasion can be determined by computed tomography (CT) scanning. A fine-cut CT can adequately demonstrate invasion of the mandible and oftentimes the extent of bone involvement (Fig. 16.3). Magnetic resonance imaging can demonstrate limited cortical invasion but often does not define the anatomical structure as well. When invasion of the mandible has been demonstrated on the scan or is highly suspected by physical examination, one needs to determine how one is going to reconstruct the defect. As discussed under surgical technique, most of the time the mandible will be involved on either its superior or medial surface. Consequently, in our experience of over 300 reconstructions using a fibular free flap, a reconstruction plate can be placed at the time of the midline lip split exposure. Occasionally, a lateral segmental mandibulectomy will need to be performed for tumors that have eroded through the mandible. In these cases, it is not possible to pre-bend a mandibular reconstruction plate before resecting the mandible (Table 16.2). Optimal surgical outcome from a reconstructive, aesthetic, and dental functional perspective is difficult with two free-floating segments of the mandible.

Virtual 3-D Presurgical Planning

Virtual three-dimensional (3-D) presurgical planning is a technology that allows for the generation of custom fitting guides and mandibular reconstruction plates. In this technique, a fine-cut 1-mm 3-D CT is performed. A 3-D construct of the mandible or the maxilla/mandibular complex is then generated on a computer image, which is amenable to 3-D rotation in multiple planes (Fig. 16.4). Once the images are generated, an online

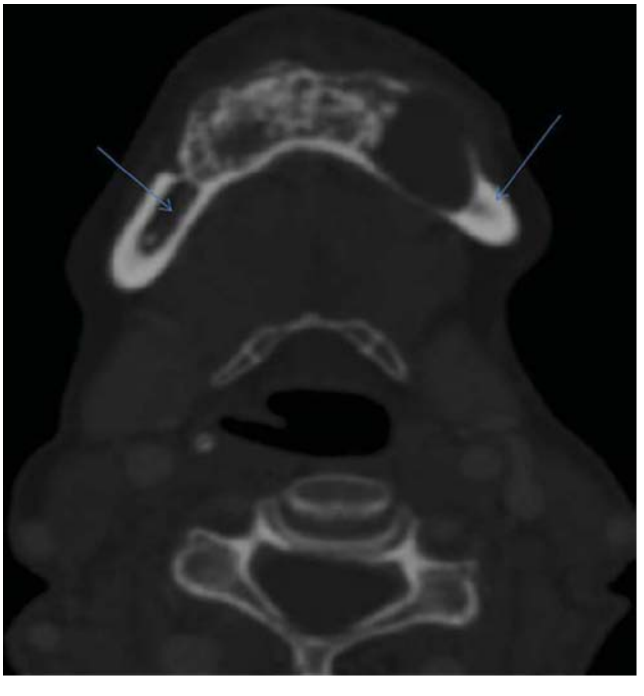

FIGURE 16.3 This CT scan demonstrates the extent of the bone that will need to be removed to obtain a clear margin (*arrows*).

TABLE 16.2 Indications for 3-D Virtual Surgical Planning
Deformity of the external cortex by an intraluminal source
Indications for 3-D virtual planning and a prebent plate
Infection or mandibular fracture
Invasion of the outer bone cortex
Invasion of the soft tissue adjacent to the outer bone cortex
Osteoradionecrosis

video conference is arranged. The surgeons (ablative and reconstructive), along with a technician who can manipulate the model in three dimensions on the computer screen, plan the ablation and the reconstruction. Determination of the precise locations for where the mandibular osteotomies will be performed and placement of the reconstruction plate is undertaken (Figs. 16.5 and 16.6). Sometimes it is difficult to predict where the exact mandibular osteotomies will be placed, and in this setting a larger reconstruction plate to accommodate for increased mandibular resection anteriorly or posteriorly can be accommodated. Cutting molds are then manufactured that fit onto the mandible to allow for precise placement of the mandibular osteotomies in those situations. This technology allows for rapid change in the placement of the mandibular osteotomies should the disease process dictate. The disadvantage to this technique is that it requires a 7- to 10-day period from the time of the initial CT scan to a video web conferencing to production and delivery of the materials. If timing permits, then the patient presents in the intraoperative setting with a cutting plate, with cutting jigs, as well as a prebent reconstruction plate. Our preference has been to use the 2.4-mm reconstruction plate, but this can be done with any of the reconstruction plates.

Once the materials are available in the operating room, the surgical resection proceeds in the usual manner and the reconstruction plate is placed after the resection. With the reconstruction plate placed, the bone reconstruction, usually involving free tissue transfer, can then be performed. An advantage to the 3-D modeling is that the osteotomies can be projected and varying lengths of the segments can be predicted based on the surgical defect.

Surgical Technique: General

The lateral segmental mandibulectomy involves resection of a lateral segment of the mandible. The surgical approach can encompass a lip-splitting technique or a non–lip-splitting visor technique. My preference is to use a lip-splitting technique in the majority of patients. This permits excellent access to the anterior and posterior mandibular segments, which is required for complete tumor resection as well as reconstruction. Once the lip has been split, the intraoral mucosal incision is connected to the incision surrounding the tumor that marks it

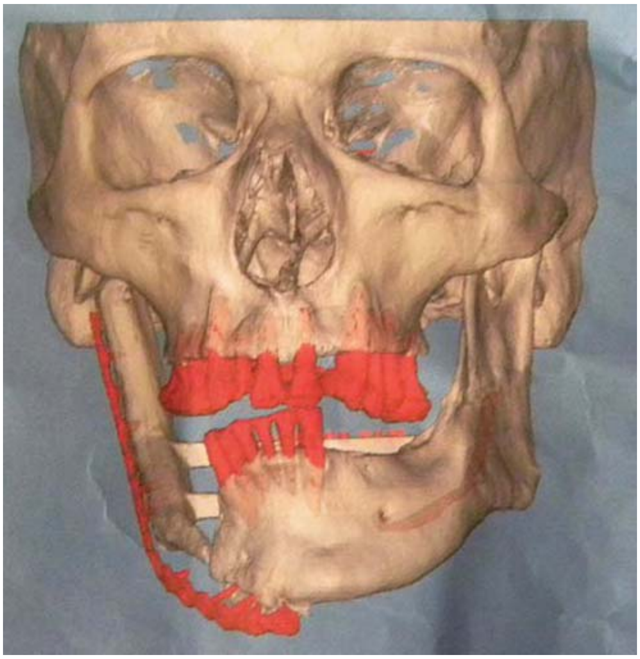

FIGURE 16.4
A fine-cut CT scan has allowed for a 3-D reconstruction of this patient's osteoradionecrosis. Surgical planning and the manufacturing of a 3-D model with a pre-bent plate can be performed.

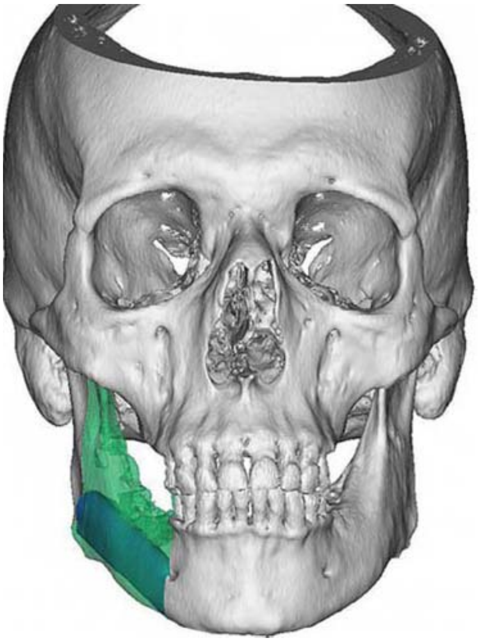

FIGURE 16.5 This model demonstrates the necrotic mandible and the proposed mandibular osteotomies. The diseased mandible is visualized, and the proposed reconstruction is seen.

boundaries. The cheek/lip flap is elevated and the tumor is resected in continuity with the lateral segmental mandibulectomy.

Description of Technique

The placement of the patient on the operating room table is dependent on the extent of the cancer and soft tissue resection. The desire to perform a neck dissection is predicated not on the mandibular invasion but on the location of the primary cancer, the extent of the primary cancer, presence or absence of neck metastasis, and the need for free tissue transfer, which will require the identification and preservation of vessels for anastamosis. When a neck dissection is required, it is usually performed prior to the cancer resection. Once the neck dissection has been performed, consideration of whether a tracheostomy should be done is undertaken. It is unusual for patients who have mandibular resections with soft tissue resection to not require a tracheotomy. In some cases of a small tumor of the alveolar ridge or retromolar trigone, it is possible to perform a lateral segmental mandibulectomy with the encompassing soft tissue and not perform a tracheostomy. Even when the defect is reconstructed with a free tissue transfer, it may be possible not to have to perform a tracheostomy. In this case

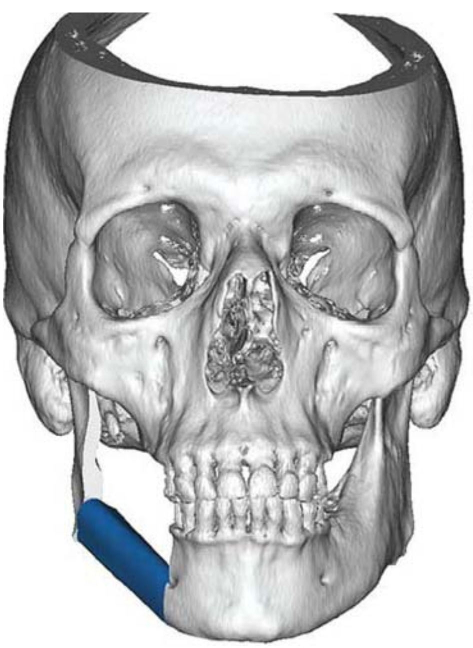

FIGURE 16.6 The diseased mandible has been removed, and the osseous free flap, in this case a fibula, is visualized.

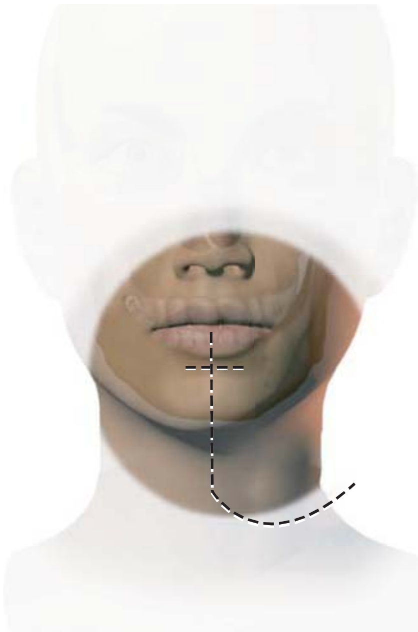

FIGURE 16.7
A lip-splitting incision is performed. Marking the vermilion border is important for closure. A *straight-line* incision down the chin is used.

the decision is whether to either extubate the patient immediately or keep them intubated overnight. This is a decision best left to the operating surgeon at the time of the initial procedure. Attention is then turned to the lip-splitting procedure. A scalpel is used to mark the vermillion border to allow for reapproximation of the lip. This is perhaps the most important step as any difference in height of the two vermillion borders on either side of the incision is immediately recognizable to patient and observers. I use a straight-line incision to connect the vermillion border down into the neck incision that was used for the neck dissection. There are many different varieties of incisions one can use including a curvilinear incision around the chin, multiple Z-plasties, or stair steps. All of these produce adequate functional and cosmetic postoperative results, provided attention to detail for closure is performed (Fig. 16.7). A scalpel is used to dissect down through the skin, and then cautery is used to dissect down through the subcutaneous tissue overlying the bone. Inferiorly in the neck the flap is elevated in a subplatysmal plane, preserving the ramus mandibularis. The cheek/lip flap is elevated until the inferior aspect of the mandible is identified. The mucosa of the lip is divided with cautery and intraorally the incision is connected to the alveolar ridge, and the incision used to resect the primary tumor. The mandible is then isolated using the cautery with the cheek/lip flap now elevated in an anterior/posterior direction off of the periosteum of the mandible (Fig. 16.8). The inferior alveolar nerve is identified as it exits the mental foramen. For most lateral segmental mandibulectomies, it is not possible to maintain continuity of the inferior alveolar mental nerve. Consequently the nerve is divided at the mental foramen. In some cases, one may want to consider grafting of the inferior alveolar nerve to the mental nerve, in which case the mental nerve should be tagged using a 4-0 silk suture that is clipped and left in the field. The cheek/lip flap is then elevated off of the mandible posteriorly until the masseter muscle is identified. In most instances the masseter muscle, using cautery, is elevated off of the angle of the mandible and up onto the ramus. The extent of the resection of the mandible is then decided and a cautery is used to mark the site of the mandibular osteotomies.

At this stage, the reconstructive surgeon usually comes in and pre-bends a 2.4-mm reconstruction plate. It is positioned with a minimum of five screw holes posteriorly and five screw holes anteriorly. Having five screw holes anterior and posterior to the proposed osteotomy allows for modification of the resection margins should that be required. The drill holes are placed in the mandible after the plate has been bent to fit, and then the screws are removed and tagged for where their location is. Once this has been performed, the plate is put on the back table and a saw is used to make the posterior and anterior mandibular osteotomies. This then allows for resection of the mandible in continuity with the intraoral or pharyngeal tumor.

Once soft tissue margins are found to be clear of cancer, the reconstruction plate can then be approximated to the mandible through the screw holes that were previously drilled. This puts the mandible back into its proper placement with good oral occlusion. A bone and soft tissue reconstruction, usually involving free tissue transfer is then performed to replace the composite defect. Once the free tissue transfer has been performed, and the tissues are revascularized, the reconstruction of the intraoral pharyngeal defect is performed. Mucosa is closed using a 3-0 semiabsorbable running suture. The neck incision is closed with deep platysma sutures and then a superficial absorbable suture. Care must be taken with the closure of the lip. Interrupted 3-0 sutures are used to reapproximate the muscle, and a suture is placed in the vermillion border at the site of the previously described mark. The mucosa is closed using an inverted vertical mattress suture, and then more 3-0 sutures are placed in the deeper tissues to reconstruct the lower lip and chin complex. A 5-0 absorbing suture is then used to

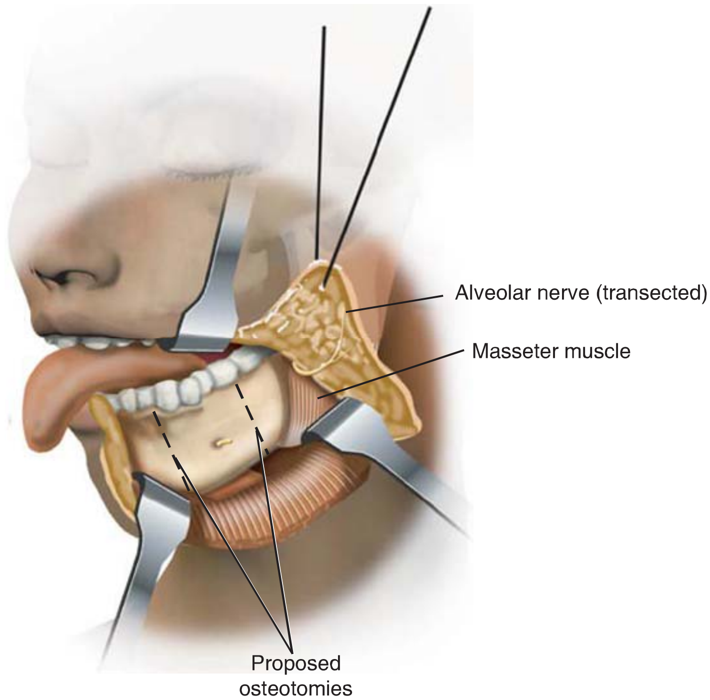

FIGURE 16.8 The cheek/lip flap has been elevated and the excellent exposure allows the cancer to be resected in continuity with the lateral mandibular segment.

approximate the skin, and drains are placed in the neck for the neck dissection. No formal dressings are placed; an antibiotic ointment is put on the wound. A feeding tube is placed either at the end of the procedure or prior to the intraoral closure. It is secured to the nose with a circumferential piece of umbilical tape that encircles the septum. Alternatively a suture through the septum can be used.

POSTOPERATIVE CARE

Suction drains are used in the neck and removed when the drainage is <30 mL/d. Most of these are removed by 5 to 7 days. Antibiotic ointment is placed on the wounds and no other dressing is used. The tracheostomy is removed when the patient's airway is stable and adequate. When the reconstructive surgeon is satisfied with healing of the intraoral component, feeding with a view toward removal of the feeding tube may commence.

COMPLICATIONS

The complications are dependent on the primary surgical procedure and ablative work that was necessary. The complications of the ablation are listed in the Table 16.3. Since most indications for a lateral segmental mandibulectomy involve free tissue transfer for reconstruction of a composite defect, the complications here involve the free tissue transfer and placement of a plate (Table 16.4).

TABLE 16.3 Complications Associated with the Oncologic Ablation
Asensate lip
Drooling
Hematoma
Infection/fistula
Lip dysfunction
Positive margins
Recurrent cancer
Speech/swallow dysfunction

TABLE 16.4 Complications Associated with the Reconstruction
Cosmesis of lip closure
Fistula
Flap failure
Hematoma
Lip dysfunction
Misalignment of mandibular reconstruction
Plate exposure/fracture/loosening
Speech/swallow issues

RESULTS

Lateral segmental mandibulectomy with a lip split incision provides excellent access to the intraoral lesion. Large cancers of the oral cavity or oropharynx can be adequately resected with tumor free margins. The reconstruction, whether it is by bending the plate once the lip/cheek complex has been elevated or if it is through 3-D modeling in cases where the lateral aspect of the mandible cannot be isolated, should allow for excellent cosmetic and functional reconstruction of the mandible with good return of the oral mandibular complex to preoperative status. The closure of the lip, cheek, and neck complex is usually performed in three layers for the lip and two layers for the chin and neck. Careful attention to detail in the lip/chin area allows for excellent functional and cosmetic outcomes. Occasionally the lip heals with a notch or there is asymmetry of the closure. Revision with standard facial plastic techniques can be performed.

PEARLS

- Prior to the surgical procedure, evaluation and planning for the extent of the mandibular resection is essential. Patients suspected of requiring mandibular resection should have preoperative CT scans to help determine the extent of the resection.
- Counseling of the patient is an important part of the treatment algorithm. Patient expectations defining whether they will remain with teeth, function with a denture, or be edentulous with no oral rehabilitation is an important conversation.
- The determination, preoperatively, whether it will be possible to bend a plate to the contour of the external cortex of the mandible intraoperatively is important in planning the reconstruction. If it is felt that a plate cannot be bent during the procedure, then thought should be given to 3-D modeling to allow for prefabrication of a mandibular reconstruction plate.
- When possible, the reconstruction plate should be applied to the mandible with screw holes drilled and placed so that the mandible can be put back into the same position after the resection.
- Closure of the lip should be done in three layers with particular attention paid to the vermilion border and maintaining the height of the lip/cheek/chin complex bilaterally.

PITFALLS

- Inadequate preoperative determination of mandibular invasion may present the reconstructive surgeon with a lateral segmental mandibular defect that was not predicted.
- Inability to place the reconstruction plate prior to mandibular osteotomy may not allow for optimal reconstruction with return to preoperative mandibular function.
- Inadequate reconstruction of the lower lip vermilion border may lead to a cosmetic defect that requires revision.
- Inadequate reconstruction of the muscular function of the lower lip may lead the patient with notching and drooling that will require segmental resection and subsequent reconstruction.

INSTRUMENTS TO HAVE AVAILABLE

- Major head and neck tray
- Oscillating saw
- Blade 4 to 5 cm long and thin and curved
- Mandibular reconstruction plating system
- Microvascular reconstruction set

Disclosure(s)

The author does not have a financial interest in any aspect of the topic being discussed.

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17 MEDIAL MAXILLECTOMY, OPEN

Ehab Hanna

INTRODUCTION

Medial maxillectomy involves removal of the lateral nasal wall and the adjoining maxillary bone medial to the plane of the infraorbital nerve. A complete sphenoethmoidectomy is also usually performed. This can be accomplished using a transfacial exposure (lateral rhinotomy), sublabial approach (facial degloving), or endoscopic endonasal approaches. This chapter discusses in detail the transfacial exposure using the lateral rhinotomy incision, which is the most widely practiced surgical approach for medial maxillectomy.

HISTORY

Small intranasal tumors are often completely asymptomatic or mimic more common benign conditions such as chronic sinusitis, allergy, or nasal polyposis. Since early detection of sinonasal tumors is probably the most important factor in improving prognosis, a high degree of suspicion is necessary to diagnose smaller lesions. Common symptoms include nasal obstruction, "sinus pressure" or pain, nasal discharge that may be bloody, anosmia, or epistaxis. Failure of these symptoms to respond to adequate medical therapy or, particularly, the presence of unilateral signs and symptoms should alert the physician to the possibility of a neoplasm and warrants further investigation by high-resolution imaging.

Extension of sinonasal tumors to adjacent structures renders the diagnosis obvious but is a late manifestation of the disease. Epiphora usually indicates obstruction of the nasolacrimal duct by tumor compression or direct invasion. Diplopia may be due to upward or lateral displacement of the globe by the tumor or more ominously due to invasion of the extraocular muscles. Blurred or reduced vision may indicate involvement of the optic nerve. Numbness or tingling of the cheek may be a symptom of perineural spread along the infraorbital nerve.

PHYSICAL EXAMINATION

Comprehensive examination of the nasal cavity should be done after topical decongestion and anesthesia using rigid or flexible endoscopy (Fig. 17.1). The presence of intranasal masses, ulcers, or areas of contact bleeding should be noted. Although unilateral "polyps" may be inflammatory, they are more commonly neoplastic. Tumors may also present as a submucosal mass without changes in the mucosa, other than displacement. Any suspicious lesions should be biopsied, preferably after high-resolution imaging has been obtained to avoid severe bleeding and/or cerebrospinal fluid (CSF) leak.

Detailed examination of the head and neck may reveal signs of extension of the tumor to adjacent structures. Soft tissue swelling of the face may indicate tumor extension through the anterior bony confines of the nose and sinuses. Inferior extension toward the oral cavity may present with an ulcer or a submucosal mass

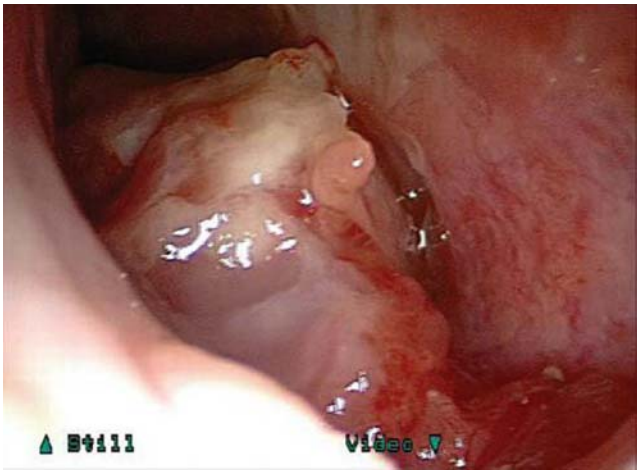

FIGURE 17.1
Endoscopic view of a tumor arising from the floor of the right nasal cavity. Biopsy revealed squamous cell carcinoma.

in the palate or the alveolar ridge. Middle ear effusion may indicate tumor involvement of the nasopharynx, Eustachian tube, pterygoid plates, or tensor veli palatini muscle. Extension to the skull base may lead to involvement of the cranial nerves resulting in anosmia, blurred vision, diplopia, or hypoesthesia along the branches of the trigeminal nerves. The presence of an associated mass in the neck may represent cancer metastatic to the cervical lymph nodes.

Evaluation of the patient with a sinonasal neoplasm and suspected extension into the orbit should include a detailed neuro-ophthalmologic examination. This usually includes detailed assessment of visual acuity, visual fields, and ocular motility.

INDICATIONS

The most common indication for medial maxillectomy is in the treatment of tumors involving the nasal cavity, lateral nasal wall, ethmoid/sphenoid sinuses, and medial maxillary sinus (Fig. 17.2). The mucosal lining of the nose includes the respiratory epithelium composed of pseudostratified ciliated columnar epithelium with goblet cells, which may give rise to squamous cell carcinoma and adenocarcinomas. These are the most common sinonasal cancers in the United States and Europe, respectively.

The olfactory epithelium gives rise to olfactory or esthesioneuroblastoma. Other neuroendocrine tumors include neuroendocrine carcinomas, sinonasal undifferentiated carcinoma (SNUC), schwannomas, and peripheral

A

B

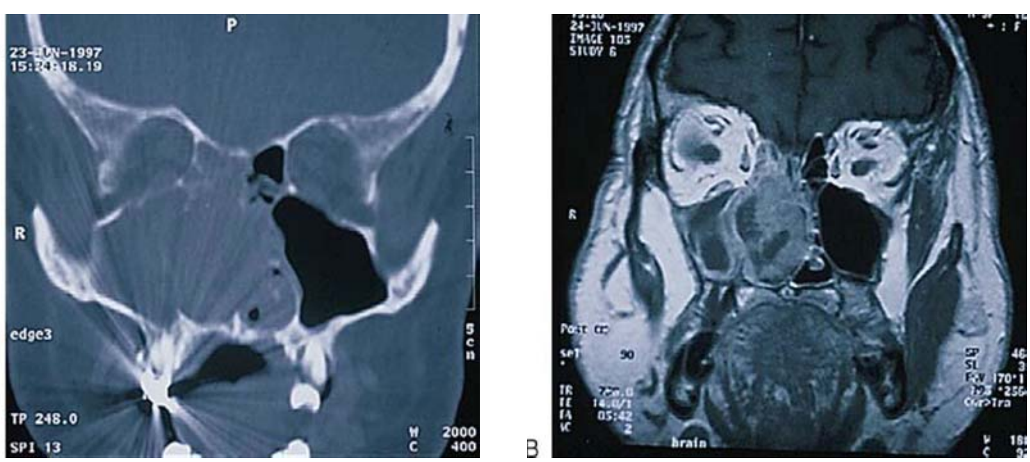

FIGURE 17.2 **A:** Coronal CT scan demonstrating opacification of the right nasal cavity as well as the maxillary and ethmoid sinuses. There appears to be destruction of the lateral nasal wall and the nasal septum. The lesion is abutting the orbital floor and the cribriform plate, but it is unclear whether or not these structures are involved. **B:** Coronal T1-weighted MRI with gadolinium of the same patient revealing that the lesion is limited to the nasal cavity and ethmoid sinuses and that the changes in the maxillary sinuses are due to retained secretions secondary to obstruction of the ostium, rather than soft tissue involvement. It also demonstrates that the lesion does not invade the orbit or the cranial base.

neuroectodermal tumors. The Schneiderian epithelium gives rise to Schneiderian (inverted) papillomas and carcinoma. Minor salivary gland tumors include adenoid cystic and mucoepidermoid carcinomas. Melanocytes within the nasal mucosa can give rise to sinonasal melanoma. Nonepithelial tumors arising from the sinonasal region include juvenile nasopharyngeal angiofibroma, hemangiopericytoma, sarcomas, and fibro-osseous lesions such as fibrous dysplasia, ossifying fibromas, and giant cell tumors. The differential diagnosis of sinonasal neoplasms is detailed in Table 17.1.

TABLE 17.1 Tumors of the Sinonasal Tract

- **Benign**
  - *Epithelial*
    - Adenoma
    - Dermoid
    - Papilloma
  - *Nonepithelial*
    - Chondroma
    - Fibroma
    - Hemangioma
    - Lymphangioma
    - Nasal glioma
    - Neurofibroma
    - Osteoma
- **Intermediate**
  - Ameloblastoma
  - Angiofibroma
  - Fibrous dysplasia
  - Giant cell tumor
  - Ossifying fibroma
  - Schneiderian papilloma
    - Cylindrical
    - Inverted
    - Papillary
- **Malignant**
  - *Epithelial*
    - Squamous cell carcinoma
      - Adenosquamous
      - Basaloid squamous
      - Differentiated (well, moderately, poorly)
    - Nonsquamous cell carcinoma
      - Adenocarcinoma
      - Adenoid cystic carcinoma
      - Hyalinizing clear cell carcinoma
      - Mucoepidermoid carcinoma
      - Neuroendocrine carcinoma
    - Melanoma
    - Olfactory neuroblastoma
    - SNUC
  - *Nonepithelial*
    - Chondrosarcoma
    - Chordoma
    - Osteogenic sarcoma
    - Soft tissue sarcoma
      - Angiosarcoma
      - Fibrosarcoma
      - Hemangiopericytoma
      - Kaposi sarcoma
      - Malignant fibrous histiocytoma
      - Rhabdomyosarcoma
    - Lymphoproliferative
      - Lymphoma
      - Plasmacytoma
      - Polymorphic reticulosis
  - *Metastatic*

CONTRAINDICATIONS

Medial maxillectomy is best suited for lesions involving the lateral nasal wall and ethmoid and sphenoid sinuses, with limited extension into the medial maxillary sinus. Extension into the lateral recess of the maxillary sinus, inferiorly into the palate, posteriorly into the pterygopalatine fossa or pterygoid plates, or posterolaterally into the infratemporal fossa requires more extensive surgery such as a total or subtotal maxillectomy. Extension superiorly into the orbit or the base of the skull may require the addition of orbital exenteration or craniofacial resection, respectively.

PREOPERATIVE PLANNING

Imaging Studies

Both computed tomography (CT) and magnetic resonance imaging (MRI) might be needed for optimum radiologic assessment of sinonasal malignancy, particularly in assessing the cranial base, orbit, and pterygopalatine and infratemporal fossae. Coronal images best delineate involvement of the orbital walls and invasion of the skull base, particularly the cribriform plate. Axial images are particularly helpful in demonstrating tumor extension through the posterior wall of the maxillary sinus into the pterygopalatine fossa and infratemporal fossae. Sagittal images are particularly helpful in evaluating extension along the cribriform plate, planum sphenoidale, and clivus.

The main advantage of CT scans is in delineating the architecture of the bones, especially in "bone windows." The addition of contrast enhancement helps to differentiate tumor from adjacent soft tissue, especially intracranially. Bone destruction and soft tissue invasion suggest an aggressive lesion, usually a malignant neoplasm. Widening or sclerosis of the foramina of the infraorbital, vidian, mandibular, or maxillary nerves may indicate perineural spread.

MRI is unsurpassed in delineating soft tissue detail, both intra- and extracranially. Obliteration of adipose tissue planes in the pterygopalatine fossa, infratemporal fossa, and nasopharynx usually indicates invasion by cancer along these boundaries. Dural thickening or enhancement is usually an indication of cancer involvement, and evaluation of critical structures such as the brain and carotid artery is best delineated by MRI. Similarly, enhancement or thickening of cranial nerves indicates perineural spread, which is better detected on MRI than CT. Perhaps one of the most significant advantages of MRI is the ability to distinguish tumor from retained secretions in the nose and sinuses (Fig. 17.2).

Positron emission tomography–computed tomography is helpful in detecting regional and distant metastasis.

Biopsy

The definitive diagnosis of a neoplasm of the nasal cavity and paranasal sinuses relies on expert histopathologic review by a head and neck pathologist to confirm the exact diagnosis prior to treatment. This is critical since the treatment and prognosis of sinonasal cancer is greatly influenced by histology.

The vast majority of sinonasal neoplasms are accessible for biopsy through an endonasal approach. A wide variety of rigid nasal endoscopes offer superb visualization of intranasal lesions with a high degree of optical resolution and bright illumination (Fig. 17.1). The application of topical anesthetics and decongestants improves visualization and allows thorough examination of the nasal cavity. The site of origin of the lesion and its relation to the nasal walls (septum, floor, roof, and lateral nasal wall) should be noted. An adequate specimen should be obtained, avoiding crushing of tissue, and submitted for histopathologic examination. If the diagnosis of lymphoma is suspected, fresh tissue should be sent in saline, rather than fixed in formalin. Most endonasal biopsies can be performed in the outpatient setting with minimal discomfort to the patient. In certain cases, the diagnosis of a highly vascular neoplasm, such as angiofibroma, may be suspected on clinical grounds. Under these circumstances, it is prudent not to perform the biopsy until imaging and angiography (possibly with embolization) are performed. Preoperative biopsy can then be performed in the operating room under controlled conditions to confirm the diagnosis before surgical resection. If a nasal mass is suspected to have an intracranial communication such as an encephalocele, meningocele, or nasal glioma, this should be confirmed with imaging to avoid inadvertent CSF leak and subsequent meningitis.

SURGICAL TECHNIQUE

The patient is orally intubated and placed under general endotracheal anesthesia. The endotracheal tube should be well secured to the contralateral oral commissure either by tape or interdental suture to avoid accidental extubation during the surgical procedure particularly if the head has to be turned to facilitate exposure.

The head is placed in a gel doughnut and the neck is slightly extended by the use of a shoulder roll. An ipsilateral temporary tarsorrhaphy should be performed to protect the eye. The face and neck are prepped and draped in a sterile fashion.

Topical decongestants should be applied to the nose to provide vasoconstriction of the nasal mucosa, which improves visualization and reduces intraoperative bleeding. Afrin nasal spray is preferred to Neo-Synephrine and topical cocaine because it does not cause cardiovascular abnormalities.

LATERAL RHINOTOMY

The lateral rhinotomy is the standard open approach for a medial maxillectomy. It is ideally suited for exposure of tumors of the nasal cavity and paranasal sinuses and can be extended by adding lip splitting, sublabial, and palatal incisions to accommodate a total maxillectomy, if necessary. It provides excellent exposure of the nasal cavity, lateral nasal wall, nasal septum, nasal roof, maxillary sinus, pterygopalatine fossa, pterygoid plates, ethmoid sinuses, medial and inferior orbital walls, sphenoid sinus, nasopharynx, clivus, and the medial aspect of the infratemporal fossa. The skin incision begins beneath the medial aspect of the eyebrow and continues along a line halfway between the medial canthus and the midline on the nasal dorsum. The incision is carried down over the nasal bone and extends inferiorly to join the medial aspect of the alar crease. The incision then follows the alar crease to the philtrum (Fig. 17.3). Placing the incision in the alar crease helps to hide the scar. The nasal cavity is entered by incising the nasal mucosa at the level of the rim of the pyriform aperture.

Elevation of the soft tissues of the cheek is done in a subperiosteal plane over the maxilla, exposing the inferior orbital nerve (Fig. 17.4A). The attachment of the medial canthal tendon to the nasal bone is released. The periorbita is elevated over the medial orbital wall exposing the lacrimal crest, the lamina papyracea, and the frontoethmoidal suture. This suture serves as a landmark for the position of the floor of the anterior cranial fossa, and when followed posteriorly, leads to the foramina of the anterior and posterior ethmoidal arteries. These arteries are cauterized with the bipolar electrocautery, clipped or ligated, and transected (Fig. 17.4B). The optic nerve is located 4 to 5 mm posterior to the posterior ethmoidal artery. The orbital floor should be dissected as far lateral as the inferior orbital fissure. The lacrimal sac is identified in its fossa between the anterior and posterior lacrimal crests. If a medial maxillectomy is performed, the lacrimal sac is elevated from the fossa, and transected, and the sac marsupialized into the nasal cavity to provide adequate drainage of the lacrimal system and to prevent stenosis and postoperative epiphora (Fig. 17.4C).

Medial Maxillectomy

After soft tissue exposure is completed, osteotomies are done as shown in Figure 17.4D. The anterior wall of the maxillary sinus superior to the level of the dental roots and medial to the infraorbital nerve is then removed. Lateral to the infraorbital foramen, the antrostomy may be enlarged to expose the zygomatic recess of the antrum.

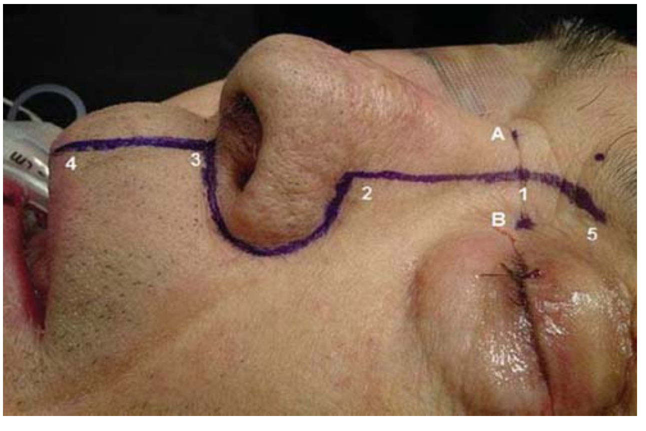

FIGURE 17.3 Lateral rhinotomy incision (*1*,*2*,*3*) and its extensions (*4* and *5*). A temporary tarsorrhaphy protects the ipsilateral globe. The basic lateral rhinotomy incision is outlined by connecting three surface points. The first point (*1*) is marked halfway between the nasion (*A*) and the medial canthus (*B*). The second point (*2*) is where the alar crease begins and the third point (*3*) is at the base of the columella. The basic incision provides adequate exposure for a medial maxillectomy. The basic incision may be extended to include a lip splitting extension (*4*) or a "Lynch"-type extension (*5*) if further exposure is necessary. The extended incision provides adequate exposure for a total maxillectomy.

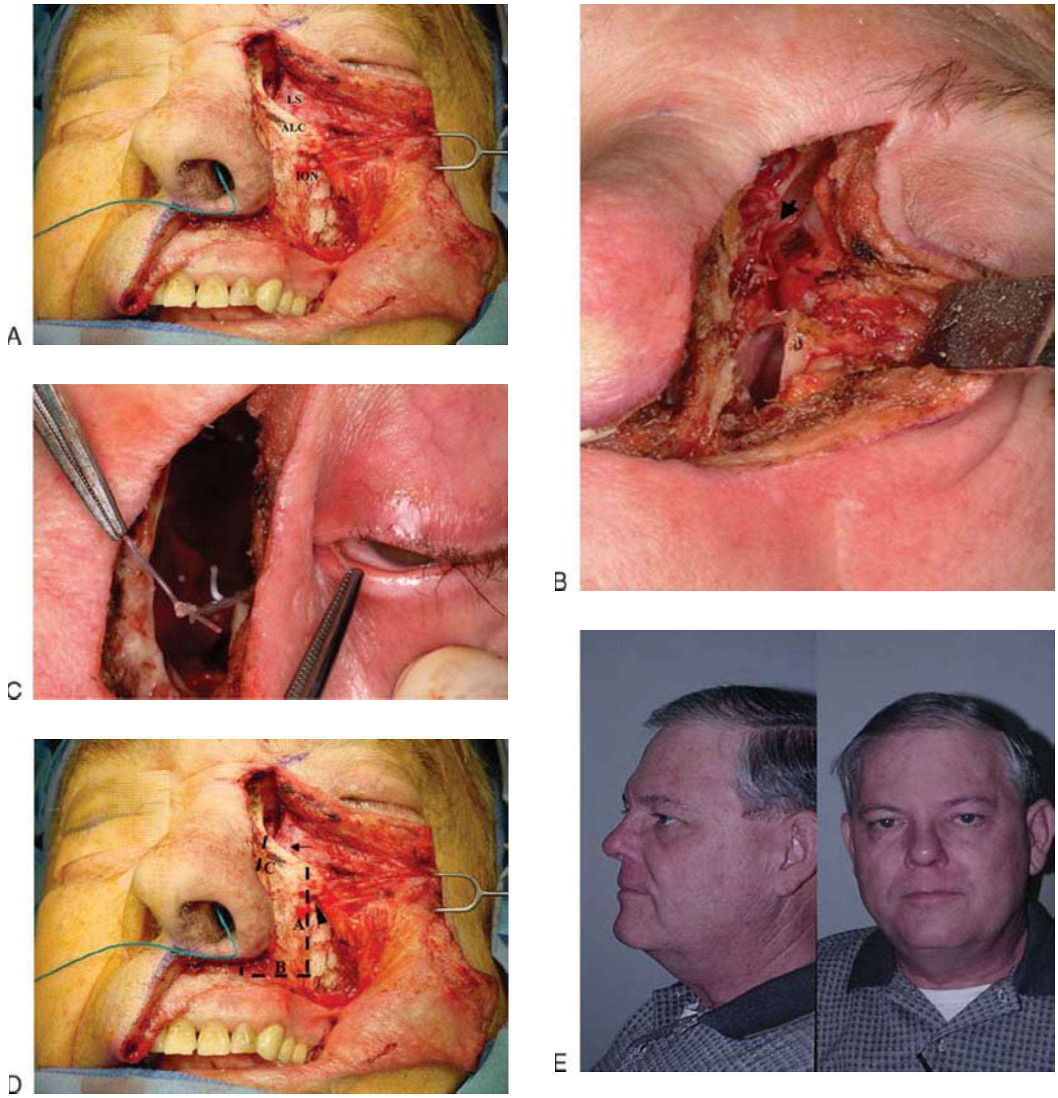

FIGURE 17.4 Medial maxillectomy. **A:** Elevation of the soft tissues of the cheek is done in a subperiosteal plane over the maxilla, and around the inferior orbital nerve (ION). The periorbita is elevated over the anterior lacrimal crest (ACL) to expose the lacrimal sac (LS). **B:** Dissection of the medial periorbita over the lamina papyracea reveals the anterior ethmoid artery (*arrow*) at the level of the frontoethmoidal suture line, which marks the level of the anterior cranial floor. The artery is coagulated by bipolar electrocautery, clipped or ligated then transected. **C:** After the lacrimal sac is transected, it is marsupialized into the surgical cavity as a dacryocystorhinostomy. Silicone stents are placed through the upper and lower canaliculi and brought into the nasal cavity to prevent postoperative epiphora. These stents are removed in 3 to 6 months. **D:** Osteotomies: (*A*) vertically medial to the infraorbital foramen (*arrowhead*), (*B*) horizontally above the level of dental roots and into the pyriform aperture, and (*C*) obliquely along the nasomaxillary suture line. If the lateral nasal wall is to be resected, the lacrimal sac (*arrow*) is transected and marsupialized into the nasal cavity. **E:** Postoperative appearance of a patient who had lateral rhinotomy incision demonstrating the excellent cosmetic appearance.

Resection of the lateral nasal wall begins with an osteotomy along the floor of the nose below the attachment of the inferior turbinate, starting at the pyriform aperture, and carried posteriorly to the posterior wall of the maxilla. With the orbit retracted laterally and protected with a malleable brain retractor, the lamina papyracea is identified and, if necessary, resected. A complete sphenoethmoidectomy is done, staying inferior to the frontoethmoidal suture in order to avoid injury to the floor of the anterior cranial fossa. The superior attachment of the middle turbinate is then transected along the roof of the nose. Posteriorly, using right-angled scissors, the incision along the lateral nasal wall is connected behind the turbinates. The specimen is then delivered and examined for adequate surgical margins with frozen section control. If the tumor involves the nasal septum, it should be included in the resection specimen by adding appropriate incisions in the septum to allow for tumor-free margins.

Closure is begun by reattachment of the medial canthal tendon to the nasal bone in its anatomic position. Meticulous multilayered closure of the lateral rhinotomy is performed and usually results in excellent wound healing and esthetic appearance (Fig. 17.4E). Adequate nonadherent nasal packing may be left for 1 to 2 days, or alternatively a water-soluble absorbable nasal dressing may be left in place.

POSTOPERATIVE MANAGEMENT

Patients should be instructed to keep the head elevated in the early postoperative period and avoid nose blowing and strenuous activity to minimize the risk of nasal bleeding. Adequate pain control and antibiotics should be given until the nasal packing is removed in 1 to 2 days. Subsequently patients are encouraged to use regular saline nasal sprays to clean the nasal cavity and help provide moisture to the nasal mucosa. This will minimize crusting and facilitate care of the surgical cavity. Sutures are removed in 5 to 7 days. Gentle debridement of the cavity to remove any loose crusts or blood clots should be done and is facilitated by using nasal endoscopy after topical decongestion and anesthesia. This may be repeated several times in the outpatient clinic until the cavity is clean and well healed.

COMPLICATIONS

The following are the possible complications of medial maxillectomy and strategies to avoid them.

- *Bleeding:* Vascular tumors such as juvenile angiofibroma may require preoperative embolization to reduce intraoperative blood loss. Intraoperative bleeding can be minimized by topical decongestants. Postoperative bleeding is best prevented by meticulous intraoperative hemostasis and adequate surgical packing in the early postoperative period. Treatment usually requires identification and electrocautery or ligation of the source of bleeding.
- *Numbness of the cheek:* This is usually temporary and can be minimized with avoiding excessive traction on the infraorbital nerve.
- *Numbness of the teeth:* This can be avoided by being certain that the inferior maxillary osteotomy is well above the roots of the teeth.
- *Infection:* Wound infection is rare. More commonly infection of the surgical cavity may occur and can be minimized by avoiding prolonged packing, antibiotic prophylaxis until the pack is removed, frequent nasal saline irrigation, and regular cavity care and debridement as described in the section on postoperative care.
- *Orbital complications:* These should also be very rare.
  - *Orbital hematoma* may present with sudden postoperative eye pain, proptosis, diplopia, or deterioration of vision. This is a surgical emergency and is best managed by immediate ophthalmologic evaluation and urgent return to the operating room to evacuate the hematoma, identify the source of bleeding, and control it. If there is a rapid deterioration of vision, a lateral canthotomy and cantholysis should be considered as an initial emergency procedure to reduce the rising intraocular pressure and preserve vision. The risk of orbital hematoma is minimized by careful dissection of the periorbita and meticulous control of the anterior and posterior ethmoidal vessels.
  - *Orbital injuries:* Inadvertent injury to the orbital contents such as the extraocular muscles or the optic nerve should be minimized by expert knowledge of the anatomy, careful and meticulous dissection of the periorbital membrane, and avoiding excessive or prolonged retraction of the globe. Corneal injuries should be avoided by performing a temporary tarsorrhaphy at the beginning of the procedure.
  - *Epiphora:* Temporary postoperative epiphora may result from swelling and edema of the transected lacrimal sac. Less commonly, this may result from stenosis and scarring of the lacrimal sac. This should be avoided by marsupializing the lacrimal sac into the nasal cavity to promote drainage and prevent scarring. If the epiphora persists, a dacryocystorhinostomy and stenting of the lacrimal system may have to be performed.
  - *Telecanthus:* This should be avoided by careful and meticulous reattachment of the medial canthal ligament.
- *Cerebrospinal fluid (CSF) leak:* This may result from inadvertent injury to the anterior skull base and can be minimized by carefully studying the anatomy of the patient's nasal and ethmoidal roof on the preoperative imaging. The superior attachment of the middle turbinate to the skull base is the most frequent site of injury, and this should be handled with extreme care. The cribriform plate, medial to the middle turbinate, is another potential site of injury since it may be significantly lower than the ethmoidal roof. Injury to the fovea ethmoidalis can be avoided by staying inferior to the plane of the frontoethmoidal suture line, which is at the level of the anterior and posterior ethmoid arteries.

If CSF leak is detected intraoperatively, it should be repaired by using nasal mucosal or fascial grafts or a vascularized nasoseptal flap. If it is detected postoperatively, it may be managed conservatively by bed rest and head elevation. Low-flow leaks will usually stop spontaneously; higher-flow leaks usually require operative intervention and repair.

RESULTS

The results depend on the type and stage of the tumor. Benign tumors such as papillomas and juvenile angiofibromas are very effectively managed by medial maxillectomy. Complete resection usually results in cure and recurrence should be extremely rare. The results of surgical treatment of malignant tumors depend on the histopathology and stage of disease. Adjuvant radiation and even chemotherapy may be needed for optimal control of the cancer.

PEARLS

- A high index of suspicion is needed to diagnose early sinonasal neoplasms. Unilateral nasal symptoms and signs such as nasal obstruction or mass should alert the clinician to the likelihood of a neoplastic rather than an inflammatory process.
- Careful nasal endoscopy after topical decongestion and anesthesia is crucial in examining the nasal cavity and providing access to biopsy to confirm the diagnosis.
- Histopathologic assessment of the cancer should be done by an experienced head and neck pathologist because of the diversity in histogenesis and natural history of sinonasal neoplasms.
- Intraoperative bleeding can obscure visualization. Topical decongestion, elevation of the head, and meticulous handling of the nasal mucosa should minimize bleeding and improve visualization.
- Avoid entering the periorbita.
- The optic nerve is located 4 to 5 mm behind the posterior ethmoid artery.
- Avoid excessive or prolonged retraction of the globe. If more exposure is needed remove more bone rather than obtaining the exposure by excessive retraction on the globe.
- Stay inferior to the frontoethmoidal suture line.
- Do not fracture the superior attachment of the middle turbinate to the skull base.
- If the medial canthal ligament is detached, meticulous and careful reattachment should be performed to avoid telecanthus.
- Regular outpatient endoscopic gentle debridement facilitates mucosal healing.

PITFALLS

- Misdiagnosis of the tumor type on a previously performed biopsy by another physician
- Inadequate imaging of the detailed anatomy of the skull base
- Being unaware that the patient is on anticoagulants
- Failure to recognize retrograde perineural spread to the base of the skull
- Underestimating the extent of orbital involvement
- Inaccurate reattachment of the medial canthal ligament resulting in telecanthus
- Inadequate drainage of the nasolacrimal duct resulting in epiphora

INSTRUMENTS TO HAVE AVAILABLE

- Head and neck soft tissue dissection set
- Microreciprocating, oscillating, and sagittal saws for maxillary osteotomies
- Nasal and sinus set including bone rongeurs, double action scissors, periosteal elevators, dissectors, curettes, chisels, drills, and straight and angled sinus forceps

SUGGESTED READING

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18 MEDIAL MAXILLECTOMY, ENDOSCOPIC

Carl H. Snyderman

INTRODUCTION

The medial maxilla separates the maxillary sinus from the nasal cavity, and medial maxillectomy has traditionally been performed to approach tumors both benign and malignant that involve the lateral nasal wall. Access is typically provided by a lateral rhinotomy or midfacial degloving approach. Excellent results have been achieved in the treatment of inverting papillomas with such an approach. Limitations of the lateral rhinotomy, however, are visualization of intranasal anatomy and the morbidity of a facial incision.

The advent of nasal endoscopy for the treatment of inflammatory sinonasal disease has resulted in the application of endoscopic techniques to the management of sinonasal neoplasms. Abundant clinical experience has confirmed that benign tumors such as inverting papillomas can be resected endoscopically with comparable outcomes and less morbidity. Endoscopic medial maxillectomy can also be applied to other benign tumors such as angiofibromas and selected sinonasal malignancies.

HISTORY

The symptoms of a sinonasal tumor are often nonspecific and include nasal obstruction, epistaxis, epiphora, hearing loss, and sinus headache. Patients often have symptoms for weeks to months and undergo multiple courses of medical treatment for allergies or sinusitis before an accurate diagnosis is made. Symptoms that suggest tumor extension beyond the nasal cavity include facial hypesthesia, visual symptoms, trismus, loose teeth, and facial swelling. Patients should be queried about visual acuity, diplopia, and sensation of the face and palate.

PHYSICAL EXAMINATION

The physical examination should include a complete examination of the head and neck supplemented with nasal endoscopy. Inspection of external features looks for asymmetry and inflammatory changes. Examination of the eyes includes an assessment of visual acuity, extraocular motility, and proptosis. Swelling inferomedial to the medial canthus may be secondary to dacryocystitis from tumor obstruction of the nasolacrimal duct or tumor growth along the duct. Otoscopy may demonstrate retraction of the tympanic membrane or a middle ear effusion. A large tumor in the nasal cavity may be evident without endoscopy, but endoscopy adds additional information regarding the origin of the tumor and areas of invasion. Nasal endoscopy establishes the vascularity of the tumor and coexistent pathology such as nasal polyposis or sinusitis. Examination of the oral cavity may reveal edema of the mucosal tissues of the hard palate on the side of the tumor. A large tumor may displace the soft palate and result in thick nasopharyngeal drainage. Palpation of the maxilla and intraoral mucosa is important to assess extension beyond the nasal cavity into the soft tissues. The neck is examined for evidence of cervical metastases. This is rare with sinonasal malignancy, and it may be difficult to distinguish between inflammatory and neoplastic lymphadenopathy. Assessment of cranial nerve function includes olfaction, eye

function (visual acuity and ocular motility), and trigeminal nerve function [sensory (V_2, V_3) and motor (V_3)]. Olfaction can be assessed using subjective or objective (UPSIT Sensonics test) measures.

INDICATIONS

Medial maxillectomy is performed for the removal of benign and malignant tumors that involve the lateral nasal wall/medial maxilla and to gain access to tumors in the masticator space and infratemporal skull base (floor of middle cranial fossa). The amount of lateral exposure is dependent on the extent of the medial maxillectomy. Addition of an anteromedial maxillectomy (Denker approach) provides maximal access; lateral limits are the mandibular ramus and temporomandibular joint.

Tumors typically requiring a medial maxillectomy include sinonasal malignancies, such as squamous cell carcinoma, adenocarcinoma, adenoid cystic carcinoma, melanoma, and undifferentiated carcinoma. Inverting papillomas require a medial maxillectomy due to their origin from the lateral nasal wall. The most common tumor that requires a medial maxillectomy for surgical access is the angiofibroma. These tumors typically extend between the medial and lateral pterygoid muscles. Other tumors in the masticator space include benign tumors of neurogenic origin such as neurilemmomas and neurofibromas.

CONTRAINDICATIONS

The floor of the maxillary sinus is at a lower level than the nasal floor, and a medial maxillectomy approach will provide limited access to this region if there is tumor involvement. Similarly, tumor extension to the anterior wall of the maxilla is better handled with an anterior transmaxillary approach. Large invasive cancers with involvement of superficial tissues are better managed with an open approach. Depending on the reconstructive needs, an open approach may also be more expedient. For example, if a temporalis muscle transposition is indicated for protection of the skull base or internal carotid artery, an infratemporal skull base approach will provide access for resection as well as reconstruction. Finally, for large tumors, such as angiofibroma, an open approach may provide more room for instrumentation (bayonet bipolar electrocautery, powered instrumentation of the tumor).

PREOPERATIVE PLANNING

Computed tomographic (CT) scans provide the most information regarding sinus anatomy and the interface between air and soft tissue/bone. Destruction of bone can occur from slow remodeling from benign processes or infiltration from malignancy. Magnetic resonance imaging (MRI) is superior for soft tissue margins when tumor extends beyond bone boundaries (orbit, masticator space) and for detection of perineural invasion. T2-weighted sequences can help differentiate mucus secretions from tumor in obstructed sinuses. Contrast enhancement of CT and MRI scans is used to distinguish benign and malignant tumors from normal tissues and establish a differential diagnosis.

If the tumor is highly vascular or extends lateral to the maxilla, preoperative angiography with embolization of the internal maxillary artery (IMA) is considered. For vascular tumors, our preferred material for embolization is Onyx (Micro Therapeutics, Inc., Irvine, CA). The proximal IMA is also occluded with coils. Even when the tumor is not hypervascular, preoperative occlusion of the IMA facilitates dissection in the masticator space without concern for vascular injury.

SURGICAL TECHNIQUE

Endoscopic medial maxillectomy varies in the amount of exposure and extent of access provided. The exposure is tailored to the needs of the operation. The patient is positioned in a supine position. If intraoperative navigation is planned, registration of the navigation system is performed at this time. If immobilization of the head is desired or it is difficult to maintain the head in the desired position, the head is placed in three-point fixation with a Mayfield head holder. Topical vasoconstriction of nasal mucosa is achieved with intranasal pledgets soaked in 0.05% oxymetazoline. Standard antibiotic prophylaxis consists of intravenous administration of a second-generation cephalosporin. The nasal vestibule and surrounding skin are prepped with a Betadine solution; antiseptic prepping of the nasal cavity or oral cavity is not necessary.

Endoscopic Middle Meatal Antrostomy (Fig. 18.1A)

The middle turbinate is medialized or partially resected if there is a large concha bullosa. The uncinate process is palpated and the site of attachment to the inferior turbinate is visualized. The uncinate process is resected with backbiting forceps, and the opening is maximally enlarged anteriorly until dense bone is encountered,

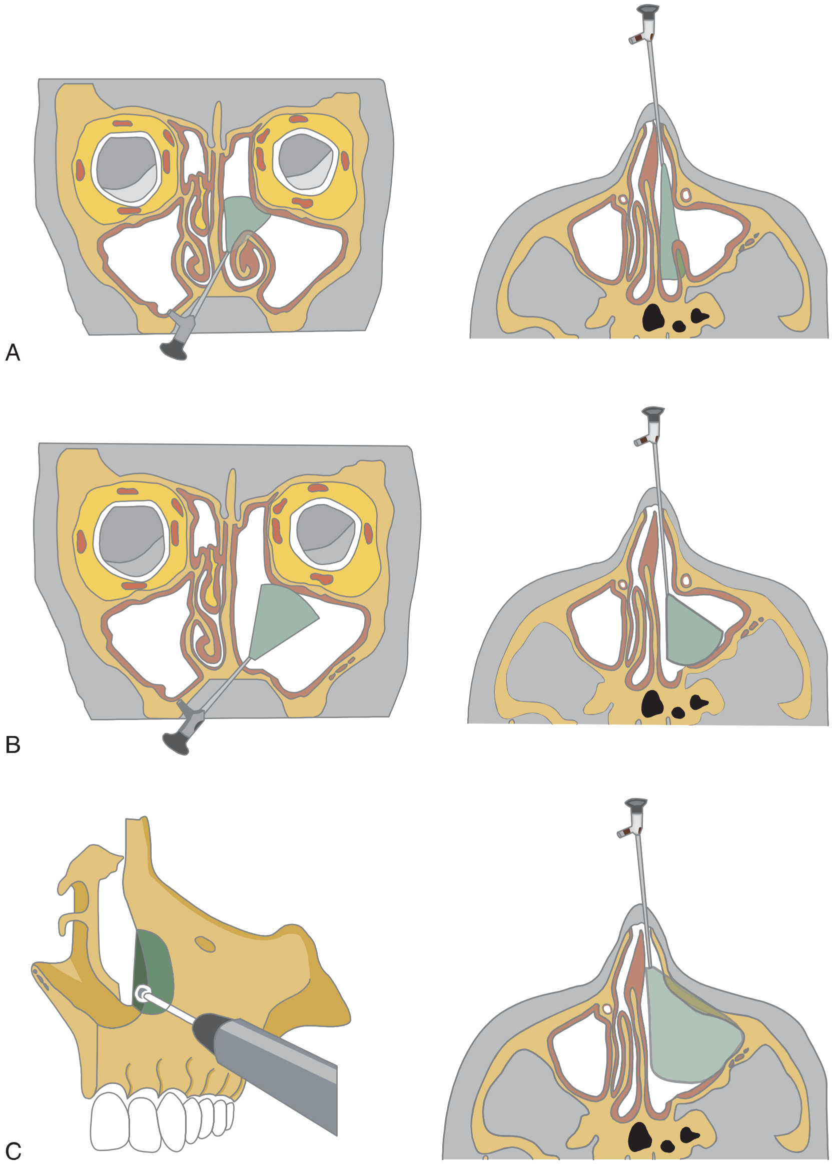

FIGURE 18.1 Extent of maxillary opening and visualization provided by **(A)** middle meatal antrostomy, **(B)** medial maxillectomy, and **(C)** medial maxillectomy and anteromedial maxillotomy.

inferiorly to the attachment of the inferior turbinate, and posteriorly to the sphenopalatine foramen (Fig. 18.2). Care is taken to avoid injury to the nasolacrimal duct anteriorly.

An endoscopic middle meatal antrostomy provides access to the medial aspect of the pterygopalatine space. The mucoperiosteum of the lateral nasal wall is elevated from the bone at the posterior margin of the antrostomy. The sphenopalatine artery exits the sphenopalatine foramen at the posterior–superior corner of the maxillary sinus. A useful landmark is the crista ethmoidalis, a small crest of bone just superficial to the foramen. The foramen is enlarged with a 1-mm 45-degree Kerrison rongeur to avoid injury to the vessel. Removal of bone continues laterally to expose the contents of the pterygopalatine space. This exposure is a prerequisite for an endoscopic transpterygoid approach.

A Silastic nasal splint is sutured to the nasal septum to prevent postoperative synechiae. Additional packing is only necessary if there is continued bleeding.

Endoscopic Medial Maxillectomy (Fig. 18.1B; Video 18.1)

A middle meatal antrostomy is first performed. The inferior turbinate is cauterized anteriorly and endoscopic scissors are used to transect the attachment to the lateral nasal wall (Fig. 18.3). The entire turbinate is removed. Anteriorly, the opening of the nasolacrimal duct is identified and sharply transected with scissors or knife (Fig. 18.4). The bone of the inferior meatus is thin at its midpoint and is easily penetrated with through-cutting

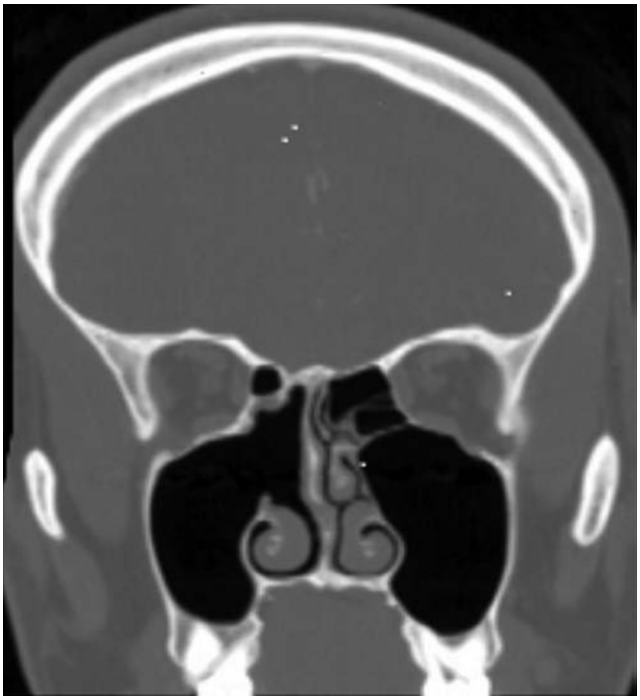

FIGURE 18.2
Coronal CT demonstrating endoscopic middle meatal antrostomy.

forceps. The lateral nasal wall is resected with through-cutting forceps, backbiting forceps, or Kerrison rongeurs. Bone is removed to the level of the nasal floor (Fig. 18.5).

An endoscopic medial maxillectomy provides access to the floor of the maxillary sinus (Fig. 18.6). It is important to note that the plane of the floor of the maxillary sinus is at a lower level than the floor of the nasal cavity. It may be necessary to drill the bone at the junction to gain full access when tumor extends to the floor of the sinus. The medial maxillectomy provides full access to the lateral limits of the pterygopalatine space.

Silastic nasal splints are usually not necessary since the inferior turbinate has been removed. Merocel tampons are placed for additional hemostasis.

Endoscopic Medial Maxillectomy with Anteromedial Maxillotomy (Fig. 18.1C; Video 18.2)

In order to gain additional lateral access and provide room for instrumentation, an anteromedial maxillectomy is performed. A mucosal incision is made intranasally with needle-tip monopolar electrocautery at the margin of the pyriform aperture. A Cottle dissector is used to identify the edge of the bone and elevate the periosteum

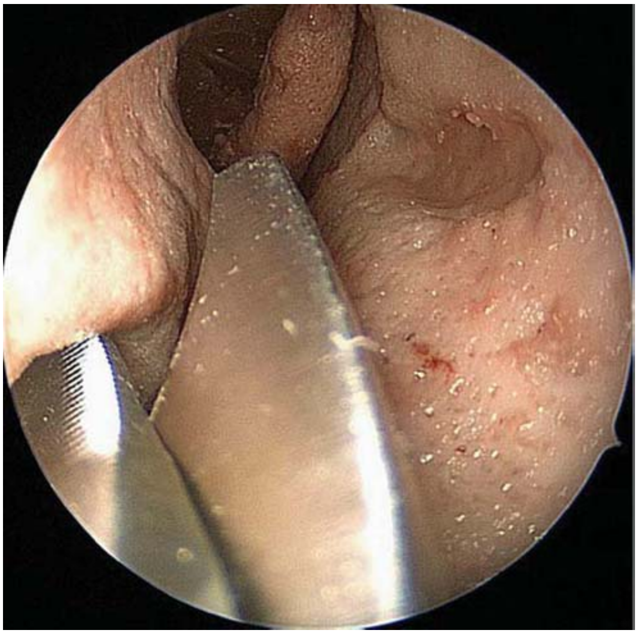

FIGURE 18.3
Anatomical dissection with transection of anterior attachment of right inferior turbinate.

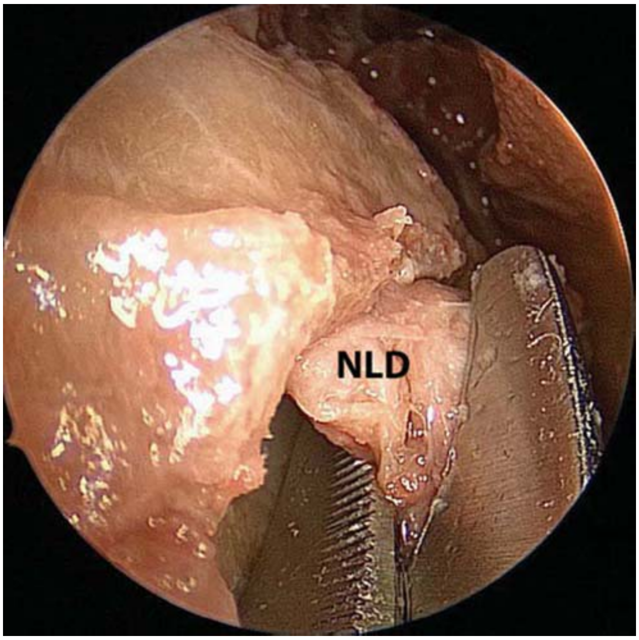

FIGURE 18.4 Anatomical dissection with sharp transection of right nasolacrimal duct (NLD) in inferior meatus.

from the anterior wall of the maxilla (Fig. 18.7). Exposure extends to the infraorbital foramen. The thicker bone at the pyriform aperture is removed with a drill, and the anterior wall of the maxillary sinus is removed with Kerrison rongeurs (Fig. 18.8). It is important to preserve the periosteum of the anterior maxilla to minimize postoperative scare contracture.

An endoscopic medial maxillectomy with anteromedial maxillotomy provides maximal access to the posterolateral wall of the maxilla and masticator space. The exposure is limited laterally by the mandible and temporomandibular joint. Tumors that extend below the level of the hard palate posteriorly or laterally are difficult to access and require a transoral approach (Caldwell Luc).

Exposed tissues of the masticator space are covered with fibrin glue and Merocel tampons are placed for additional hemostasis.

POSTOPERATIVE MANAGEMENT

Nasal packing can be removed within 24 hours of surgery, often while the patient is in the recovery room. Patients can be discharged on the same day as surgery or the following day if there is significant dissection beyond the maxillary sinus. In particular, dissection of the masticator space may result in significant

FIGURE 18.5 Anatomical dissection with removal of medial wall of maxilla.

FIGURE 18.6
Axial CT demonstrating extent of endoscopic medial maxillectomy.

postoperative pain and trismus. The patient is instructed to use saline nasal spray and irrigations to clean the nasal cavity and maintain an airway. Topical nasal decongestants are not typically used and antibiotics are discontinued as soon as nasal packing is removed. Nasal splints are removed in 1 week, and gentle endoscopic debridement is performed in the clinic.

COMPLICATIONS

Minor complications include nasal crusting, rhinosinusitis, and nasal congestion. Normal nasal physiology is disrupted by the surgery and may predispose the patient to excessive drying and crusting of the surgical cavity as well as recurrent/chronic infection. These can be managed with saline irrigations and periodic debridements.

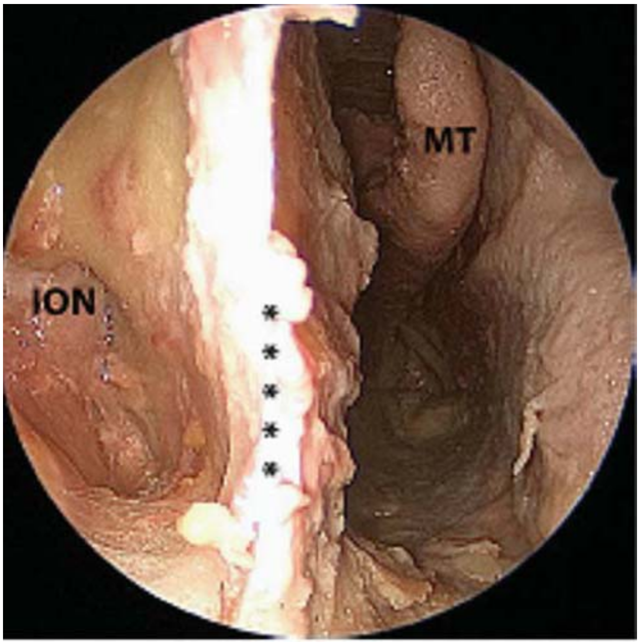

FIGURE 18.7
Anatomical dissection with exposure of right pyriform aperture (*asterisks*). The periosteum has been elevated from the anterior wall of the maxilla to the infraorbital nerve (ION). MT, middle turbinate.

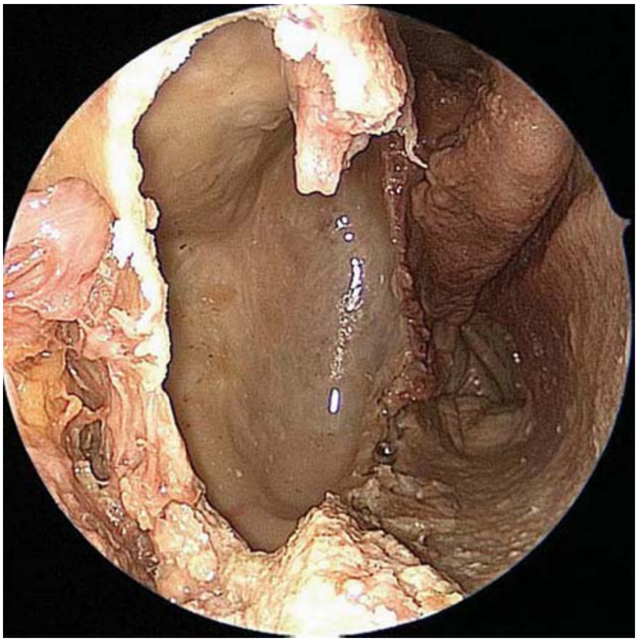

FIGURE 18.8 Anatomical dissection with completed right anteromedial maxillotomy.

The most common complication requiring intervention is postoperative hemorrhage. Minor bleeding from the mucosa can be managed with a topical decongestant nasal spray for a few days. Severe epistaxis is usually from the sphenopalatine artery and is managed with nasal packing or endoscopic surgery (cautery and/or ligation).

Epiphora can result from injury to the nasolacrimal duct during a middle meatal antrostomy or postoperative scarring following transection of the nasolacrimal duct. The nasolacrimal duct should be transected sharply to minimize scarring. In most cases, a fistula will form without the need for stenting of the duct. Alternatively, Crawford Silastic lacrimal stents can be placed following dilation of the lacrimal punctum.

Hypesthesia of the cheek and upper lip in the distribution of the second division of the trigeminal nerve (V2) is the result of trauma to the infraorbital nerve. The neurovascular bundle is often dehiscent along the orbital floor and may be injured with removal of mucosa or cauterization. The greater palatine nerve is a branch of V2 and travels vertically in the palatine bone from the pterygopalatine space to the hard palate (greater palatine foramen). Injury results from excessive removal of bone from the medial maxilla posterior to the sphenopalatine foramen. This results in hypesthesia of the ipsilateral palatal mucosa.

Cosmetic deformity with retraction of the nasal ala is a consequence of an anterolateral maxillotomy with loss of periosteum. This can be minimized by limiting the vertical dimension of the maxillotomy at the pyriform aperture and amount of soft tissue resection.

RESULTS

I have used endoscopic medial maxillectomy for a wide variety of pathologies within the nasal cavity and maxillary sinus and for access to areas beyond the maxillary sinus. Representative examples include:

Epistaxis: An endoscopic middle meatal antrostomy provides access for ligation of the sphenopalatine artery in patients with severe posterior epistaxis (Fig. 18.9). The antrostomy extends to the sphenopalatine foramen, and the medial pterygopalatine space is exposed to gain access to the proximal trunk of the sphenopalatine artery.

Spontaneous cerebrospinal fluid (CSF) leak of lateral sphenoid sinus: An endoscopic middle meatal antrostomy is also the prerequisite for an endoscopic transpterygoid approach to the lateral recess of the sphenoid sinus and middle cranial fossa. Spontaneous CSF leaks of the sphenoid sinus typically occur in the lateral recess of a well-pneumatized sphenoid sinus (Fig. 18.10). Here, a meningoencephalocele was repaired with a free mucosal graft.

Inverting papilloma: Inverting papillomas arise from the lateral wall of the nose in the region of the middle meatus and may grow into the maxillary sinus. Small tumors may only require a large antrostomy to confirm clear resection margins. An endoscopic medial maxillectomy is necessary to remove tumor that is filling the sinus (Fig. 18.11). Tumor invasion of mucosa of the anterior or lateral maxilla may require an anterior transmaxillary approach in addition to the medial maxillectomy. Thickened bone at the site of origin needs to be drilled to remove all remnants of the tumor.

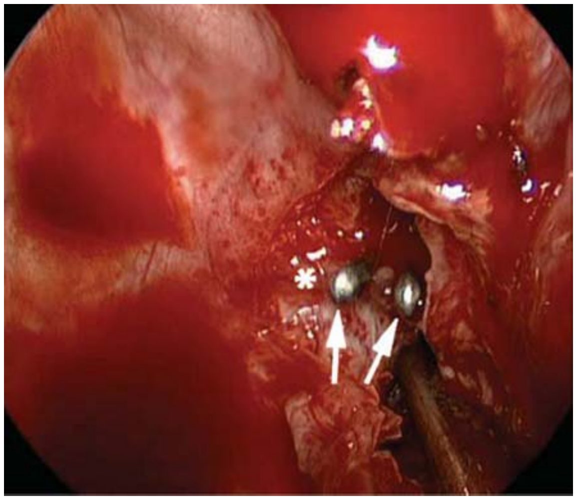

FIGURE 18.9
Surgical photograph demonstrating clipping (*arrows*) of right sphenopalatine artery (*asterisk*) for epistaxis. The maxillary antrostomy provides additional room for instrumentation and identification of all branches.

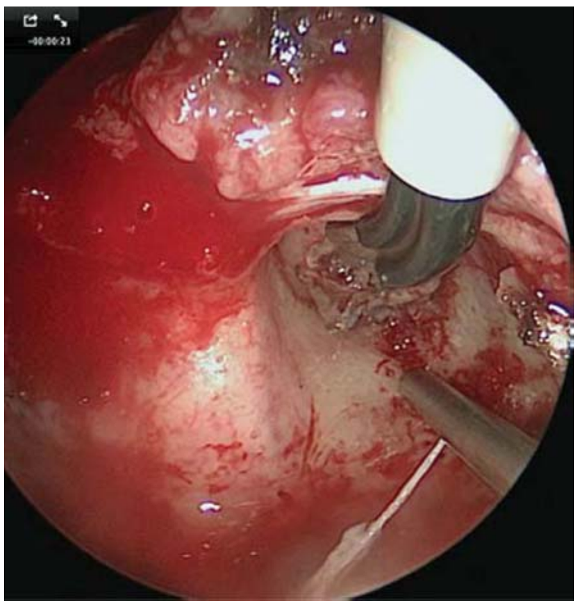

FIGURE 18.10
Meningoencephalocele in the lateral recess of the left sphenoid sinus. A large middle meatal antrostomy provides access for a transpterygoid approach to the lateral recess of the sphenoid sinus. The encephalocele is reduced with bipolar cauterization.

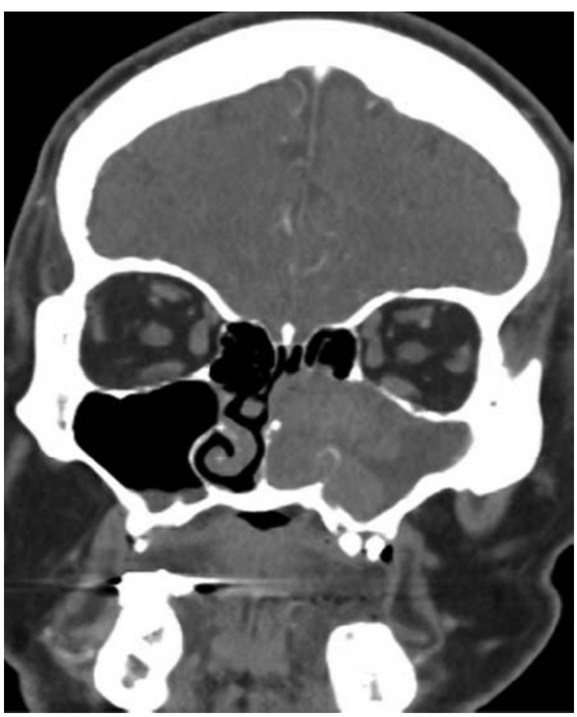

FIGURE 18.11
Inverting papilloma filling the left maxillary sinus requires a medial maxillectomy or Caldwell Luc approach to clear tumor from the sinus.

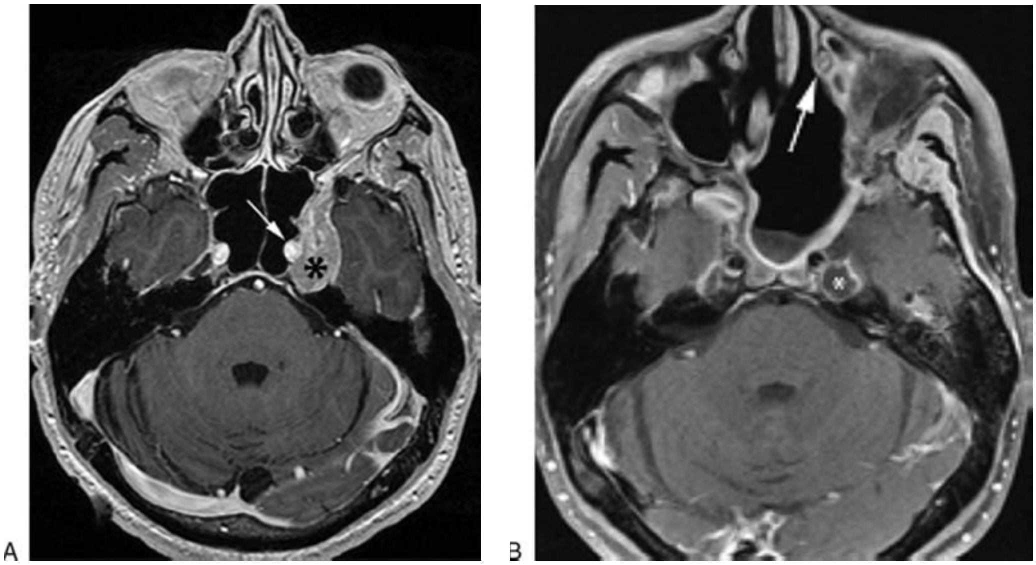

FIGURE 18.12 Preoperative MRI **(A)** of adenoid cystic carcinoma with perineural spread along the trigeminal nerve to involve left Meckel's cave (*asterisk*) (*arrow*—ICA). Postoperative MRI **(B)** demonstrates extent of medial maxillectomy for transpterygoid approach to middle cranial fossa. Note the preserved nasolacrimal duct (*arrow*) at the anterior margin of the defect (*asterisk*—Meckel's cave defect).

Adenoid cystic carcinoma of middle cranial fossa: In this case, an adenoid cystic carcinoma of minor salivary gland origin with perineural invasion into Meckel's cave can be removed using an endoscopic medial maxillectomy approach (Fig. 18.12).

Angiofibroma: Access to the lateral margin of an angiofibroma can be achieved in most cases with a medial maxillectomy ± anteromedial maxillotomy. An alternative is to combine an endonasal approach with a sublabial transmaxillary approach. Figure 18.13 demonstrates axial (A) and coronal (B) views of a postoperative CT following a medial maxillectomy with anteromedial maxillotomy for a massive angiofibroma.

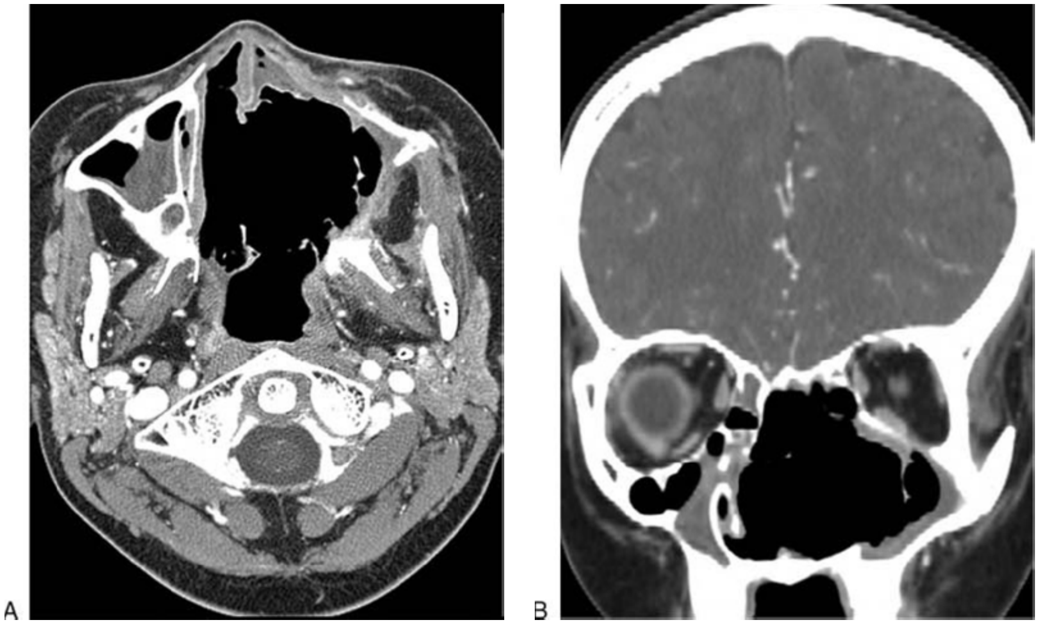

FIGURE 18.13 Axial **(A)** and coronal **(B)** CT of postoperative defect following endoscopic endonasal excision of a massive angiofibroma that extended to the middle cranial fossa. Access to the infratemporal and masticator spaces was provided by an endoscopic medial maxillectomy with anteromedial maxillotomy.

PEARLS

- Resection of the inferior turbinate improves visualization and access.
- Identification of the opening of the nasolacrimal duct in the inferior meatus is facilitated by submucosal dissection of the inferior meatus.
- The pyriform aperture is palpated with a Cottle elevator to identify the site for incision.

PITFALLS

- The branch of the sphenopalatine artery to the inferior turbinate enters the turbinate posteriorly and is a potential source of postoperative epistaxis.
- The greater palatine nerve descends in the bone of the medial maxilla posterior to the sphenopalatine artery and is susceptible to injury if bone removal extends posterior to the artery.
- The nasolacrimal duct should be dissected circumferentially and transected sharply to prevent postoperative stenosis.
- The plane of the maxillary sinus floor is inferior to the floor of the nasal cavity so that access may be limited with an endonasal approach.
- The periosteum of the anterior maxilla should be preserved to prevent scar contracture of the nasal ala with an anteromedial maxillotomy.

INSTRUMENTS TO HAVE AVAILABLE

- Navigation system
- Endoscopic sinus surgery set
- Kerrison bone rongeurs
- Needle-tip and suction monopolar electrocautery (insulated)
- Endoscopic pistol-grip bipolar electrocautery
- Endoscopic drill with 4-mm hybrid diamond bits
- Endoscopic pistol-grip adjustable hemoclip applier
- Silastic Doyle splints
- Merocel nasal tampons
- Silastic Crawford lacrimal stents

SUGGESTED READING

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19 ENDOSCOPIC SURGERY IN THE MANAGEMENT OF SINONASAL MALIGNANCIES

Piero Nicolai

INTRODUCTION

Malignancies of the sinonasal tract are rare, accounting for 3% of all cancers of the head and neck, and present several unique features. Notably, in spite of the widespread use of endoscopy in routine daily practice and progress in imaging techniques, diagnosis is established at an advanced stage in view of the nonspecific symptoms associated with the early phase of growth, which are commonly interpreted as allergy or rhinosinusitis. A second hallmark is the extreme histologic diversity (Table 19.1) that impacts biologic behavior and, consequently, prognosis. In view of their rarity and the lack of prospective comparative studies, most authors can only provide evidence at levels III and IV, and treatment recommendations are based on levels C and D.

The mainstay for treatment of malignancies of the sinonasal tract has traditionally included surgery through an external transfacial approach, followed by adjuvant radiotherapy. From a surgical standpoint, a major step forward in improving the prognosis of tumors with superior extension toward or through the anterior skull base was the introduction in 1963 by Ketcham of anterior craniofacial resection. This procedure has offered previously hopeless patients a possibility of 5-year overall survival of approximately 54%, with, however, a nonnegligible rate of both complications and mortality (33% and 4%, respectively).

Transnasal endoscopic surgery was introduced in the late 1970s as a more physiologic and conservative treatment for sinonasal inflammatory disorders. As a result of the rapidly growing expertise in the field, refinements in imaging diagnosis, and impressive technologic advances in surgical instruments, the indications have expanded to incorporate benign and malignant lesions involving the sinonasal tract and adjacent anatomic areas. The largest experience with malignancies has been accumulated in the management of nasoethmoidal tumors, since for maxillary cancers, external approaches remain the best option.

HISTORY

Unilateral nasal obstruction is the most frequent presenting symptom of sinonasal malignancies, which should always alert the general practitioner and warrant otolaryngologic examination. Other possible associated manifestations are epistaxis, serosanguineous nasal discharge, and impairment of the sense of smell. Orbital signs and symptoms, such as epiphora, dislocation of the globe, diplopia, impairment of visual acuity, and/or movement of the globe, indicate the presence of compression/invasion of the orbital contents. Intracranial extension of the lesion can occur without headache or other neurologic symptoms (Fig. 19.1). The presence of enlarged cervical lymph nodes suggestive of metastasis is an extraordinarily rare event, which is usually seen in high-grade cancers or olfactory neuroblastoma.

PHYSICAL EXAMINATION

Otolaryngologic evaluation in a patient with signs/symptoms suspicious for a nasoethmoidal lesion should include inspection of the face and neck and an endoscopic examination after nasal decongestion. The former

TABLE 19.1 Histologic Classification of Sinonasal Malignancies (Modified from WHO Classification)
Epithelial Tumors
Adenocarcinoma (intestinal-type and nonintestinal-type adenocarcinoma)
Carcinoma of salivary gland origin
Lymphoepithelial carcinoma
Sinonasal undifferentiated carcinoma
Small cell carcinoma, neuroendocrine type
Squamous cell carcinoma
Soft Tissue Tumors
Angiosarcoma
Fibrosarcoma
Leiomyosarcoma
Malignant fibrous histiocytoma
Malignant peripheral nerve sheath tumors
Tumors of Bone and Cartilage
Chondrosarcoma
Chordoma
Mesenchymal chondrosarcoma
Osteosarcoma
Hematolymphoid Tumors
Neuroectodermal Tumors
Ewing sarcoma
Melanotic neuroectodermal tumor of infancy
Mucosal malignant melanoma
Olfactory neuroblastoma
Primitive neuroectodermal tumor
Germ Cell Tumors
Sinonasal teratocarcinosarcoma
Sinonasal yolk sac tumor (endodermal sinus tumor)
Teratoma with malignant transformation
Secondary Tumors

aims to identify a swelling in the medial canthal, frontal, or maxillary area; to check the motility of the globes; and to assess sensitivity in the territory of the maxillary nerve. Palpation of the neck, with special reference to levels I–II to disclose any suspicious lymph nodes, is recommended. The advent of rigid and flexible endoscopes has substantially improved the diagnosis of sinonasal diseases. On occasion, the presence of a marked septal deviation can impair visualization of the posterior aspect of the nasal cavity even after decongestion and the use of a flexible endoscope. In this case, it is advisable to explore the nasopharynx through the contralateral nasal fossa to rule out the presence of a mass posteriorly growing through the choana. The most common endoscopic finding in nasoethmoidal malignancies is that of a lesion located lateral or medial to the middle turbinate, varying in color and appearance in relation to the vascularization and the amount of necrosis. In patients complaining of frequent epistaxis, clearly indicating the hypervascularized nature of the lesion, as in olfactory neuroblastoma or melanoma, the inspection must be performed with great caution to avoid any major bleeding. Not infrequently, the lesion completely fills the nasal cavity, so that it is impossible to be certain of the site of origin. In locally advanced lesions, the presence of neoplastic tissue can be observed in both nasal fossae; however, more frequently the nasal septum is simply displaced but not invaded by the tumor.

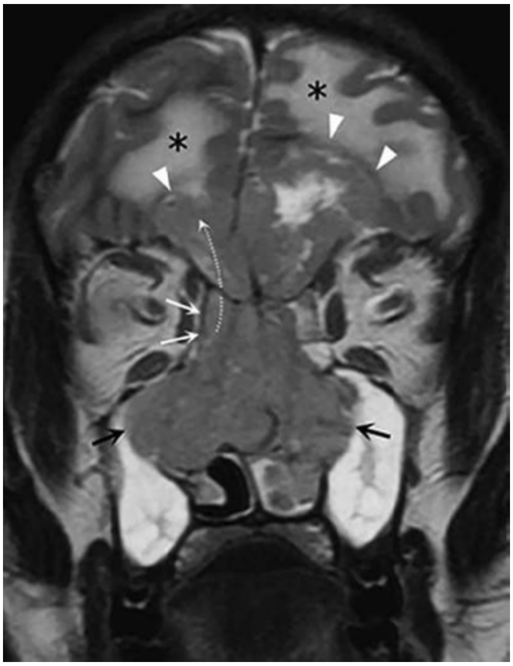


FIGURE 19.1 High-grade nonintestinal-type adenocarcinoma of the right ethmoid sinus in a 45-year-old man, presenting with a 2-month history of bilateral nasal obstruction, with no neurologic symptoms. In the T2-weighted coronal section, the cancer shows intermediate signal intensity, lower than the blocked fluid inside the maxillary sinuses (*black arrows*). The cancer extends into the left nasal cavity and ethmoid sinus and invades the perpendicular plate. The lesion contacts both the floor and the medial wall of the right orbit (*white arrows*), without signs of displacement or invasion. Though the low signal of the floor of the anterior cranial fossa can be seen on both sides, the cancer largely extends intracranially through the floor (*dotted curved arrow*). Cerebral edema (*asterisk*) surrounds the outline of the intracranial tumor mass (*arrowheads*). The patient underwent a combined resection (transnasal endoscopic with transfrontal craniotomy) followed by adjuvant radiotherapy.

INDICATIONS

Since the first reports, indications have been to some extent redesigned as a consequence of the increasing surgical expertise and progressive validation of the results obtained. The early experiences included tumors limited to the nasoethmoidal complex and not extending to the anterior skull base, which were managed by endoscopic transnasal resection (ETR). In view of the parallel, increasing expertise acquired in the repair of cerebrospinal fluid (CSF) leaks, it soon became evident that endoscopic resection could be extended to include the anterior skull base with the adjacent dura, olfactory bulb, and tract, mono- or bilaterally according to specific needs (endoscopic transnasal resection with craniectomy, [ETRC]). If the American Joint Committee on Cancer (AJCC) staging system is considered, all T_1-T_2 and selected T_3-$T_{4a\text{-}b}$ lesions of the nasoethmoidal complex can be resected through an endoscopic approach.

CONTRAINDICATIONS

The major concern when assessing the feasibility of curative endoscopic resection for sinonasal malignancies is the local extent of the lesion. However, there are situations such as severe comorbidities or the presence of distant metastasis that suggest that the patient is not a good candidate for curative surgery. However, in the latter setting, palliative endoscopic resection may have a role in relieving symptoms such as nasal obstruction or preventing the evolution toward blindness.

Current contraindications in terms of local extent of the lesion for endoscopic resection are summarized in Table 19.2. Erosion of the nasal bones or the floor of the nose, involvement of the maxillary sinus with the

TABLE 19.2 Contraindications for Endoscopic Resection of Sinonasal Malignancies

Erosion of the nasal bones or the floor of the nose
Erosion of the pterygoid plates
Extensive involvement of the lacrimal apparatus
Infiltration of the bony walls of the maxillary sinus (except the medial)
Invasion of the orbital contents
Invasion of the pterygopalatine fossa
Involvement of the anterior wall and/or superior aspect of the frontal sinus
Lateral extension of dural resection over the roof of the orbit
Massive involvement of the brain

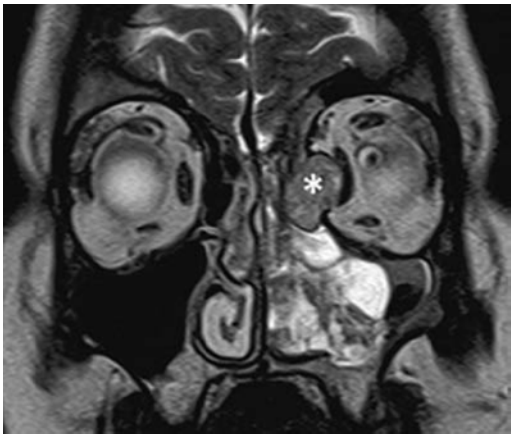


FIGURE 19.2
Inverted papilloma associated with squamous cell carcinoma in a 63-year-old man. T2-weighted coronal plane shows expansile lesion filling the left nasal fossa. Evident orbital infiltration by the solid component directly in contact with the medial rectus muscle (*asterisk*) can be observed.

exception of the medial wall, invasion of the pterygopalatine fossa, erosion of the pterygoid plates, and involvement of the anterior wall and/or superior aspect of the frontal sinus are all situations that require a combination of an endoscopic with an external approach (otherwise named "endoscopic-assisted external procedure.") When the lacrimal apparatus or orbital contents are simply compressed or dislocated by the tumor, as is frequently the case in adenocarcinomas, resection can be performed endoscopically, while obvious infiltration requires a combined approach and, after intraoperative histologic confirmation, clearance of the orbit (Fig. 19.2).

In tumors extending to the anterior cranial fossa, a clear limitation for an endoscopic procedure is lateral involvement of the dura beyond the meridian of the orbit, which renders the reconstruction of the dural defect extremely challenging. A second critical issue is involvement of the brain. Apart from any considerations about the prognosis of a patient with involvement of the brain, which is almost invariably ominous, tumors with minimal extension and without major arterial vessel involvement can be easily managed endoscopically, while in all the other advanced situations (Fig. 19.1), resection is more safely accomplished by combining it with a transfrontal craniotomy.

It is also worth mentioning that for some very aggressive histologies (i.e., sinonasal undifferentiated carcinoma, neuroendocrine carcinoma, Ewing sarcoma), which almost invariably present at an advanced local stage, treatment should start with induction chemotherapy to select the next step (surgery or chemoradiation) or directly include chemoradiation. In fact, these tumors tend to have a good response to chemotherapy, which is also used with the intent to prevent early systemic dissemination of the disease. Surgery, irrespective of the technique (endoscopic or combined), plays an important role in the context of multimodality therapy, but not as a first step.

PRETREATMENT PLANNING

The general recommendation when faced with a patient whose symptoms and physical examination are suspicious for a neoplastic lesion of the nasoethmoidal complex is to first perform imaging studies followed by biopsy. Both multislice computed tomography and magnetic resonance (MR) with contrast medium are commonly requested to obtain better delineation of bone and soft tissue extension, respectively. In my experience, MR alone after gadolinium administration and with the acquisition of all the required sequences (Turbo Spin-Echo T2, Spin-Echo T1 pre- and postcontrast agent, Gradient-Echo T1-weighted postcontrast) is accurate enough to obtain the key information for treatment planning (Fig. 19.3):

1. Differentiation of neoplastic tissue from the associated inflammatory modifications within the ethmoid, sphenoid, maxillary, and frontal sinuses
2. Growth of the lesion through the anterior skull base and the periorbita
3. Spread along dura and nerves (i.e., great palatine, vidian, maxillary)
4. Critical relationships with the lacrimal apparatus, optic nerve, internal carotid artery (ICA), and cavernous sinus
5. Involvement of the brain (with or without perilesional edema) and critical contact or encasement of arteries (i.e., orbitofrontal)
6. Erosion of nasal bones or hard palate

MR can also suggest the histologic nature of the tumor based on specific features (Fig. 19.4) and accurately depicts the presence of metastatic retropharyngeal nodes, which can be involved in some high-grade malignancies.

The role of positron emission tomography–computed tomography (PET-CT) in the pretherapeutic assessment of sinonasal malignancies still needs to be elucidated. Its use seems reasonable in high-grade

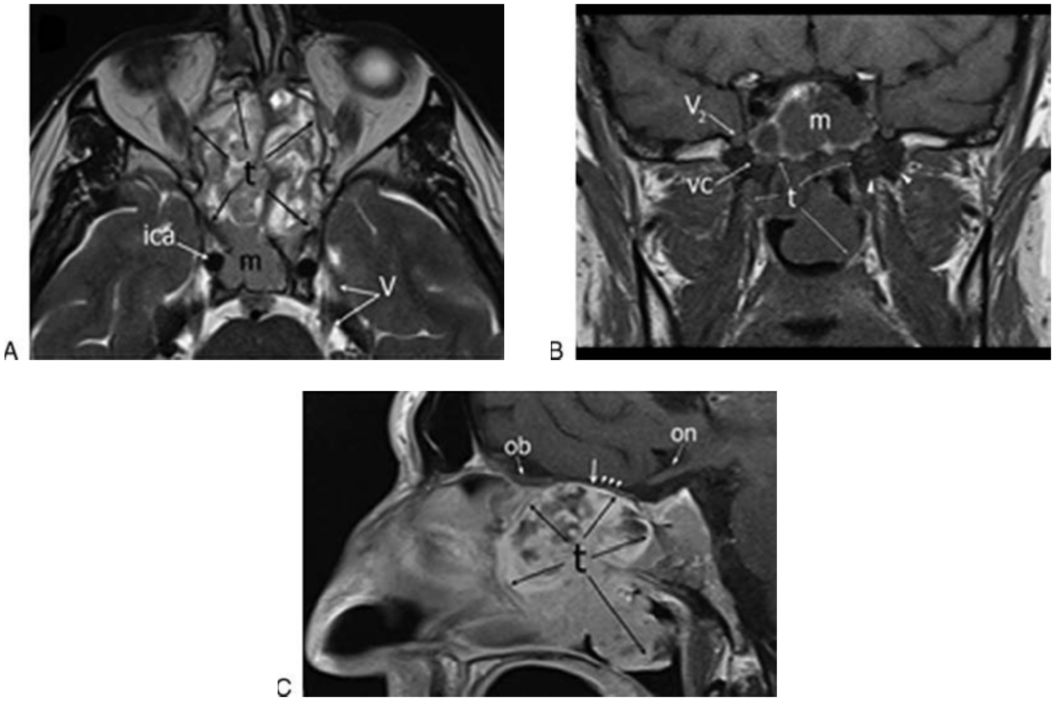


FIGURE 19.3 Adenoid cystic carcinoma arising from the ethmoid sinus in a 56-year-old man. In (**A**), the T2-weighted axial plane shows the tumor (t) contacting both medial orbital medial and blocking the sphenoid sinuses, filled with dehydrated mucus (m); ICA, internal carotid artery; V, trigeminal nerve. In (**B**), the unenhanced T1-weighted coronal scan demonstrated that the exophytic portion of the tumor projects downward into the nasopharynx, while the infiltrating component reaches the ipsilateral and contralateral floor of the sphenoid sinus (*curved dotted arrow*). The lesion reaches the pterygoid processes where sclerotic changes of the spongiotic bone result in hypointense signal (*arrowheads*). V_2: maxillary nerve; vc, vidian canal and nerve; m, mucus inside the sphenoid sinuses surrounded by a more dehydrated layer (*asterisk*). In the sagittal plane (postcontrast agent T1-weighted plane) (**C**), the tumor is characterized by an ethmoidal component less homogeneous and more enhancing than the one growing into nasopharynx. The tumor abuts the planum sphenoidale where it is confined by a double layer signal, made by bone (hypointense, *white arrow*) and dura mater (hyperintense, uniform thickness, *arrowheads*); ob, olfactory bulb; on, optic nerve.

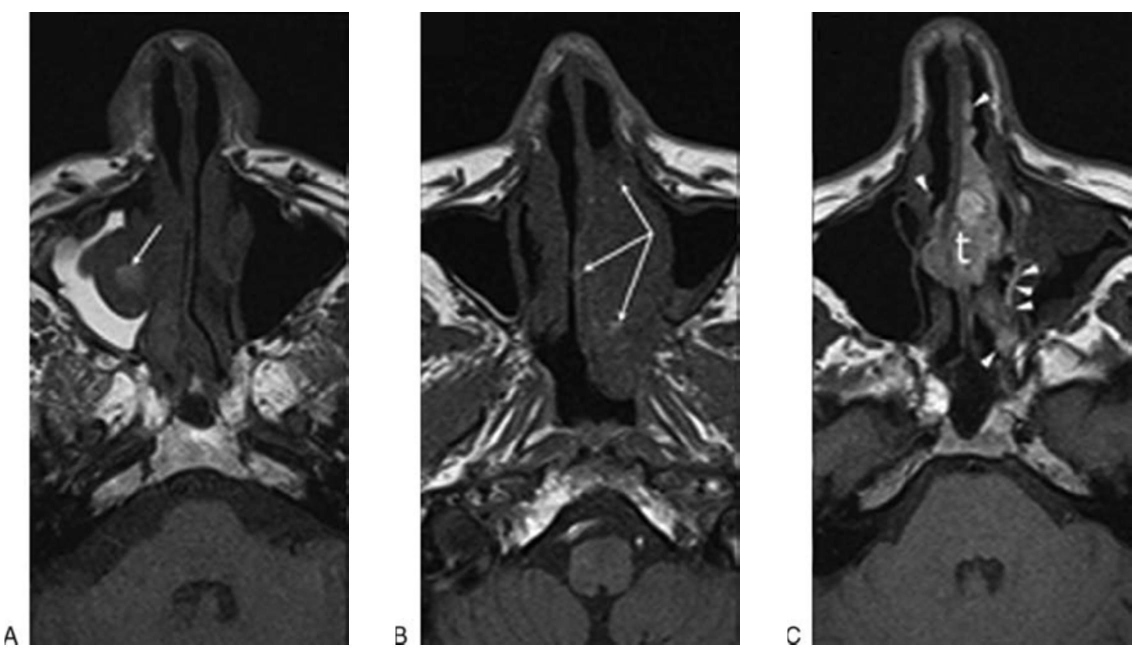


FIGURE 19.4 Unenhanced T1-weighted axial plane in three patients with malignant melanoma of the nasal mucosa. **A:** The rounded hyperintensity inside the lesion is due to the recent biopsy with a small hemorrhage (*arrow*). **B:** Scattered small hyperintense areas inside the lesion (*arrows*) raise the suspicion of malignant melanoma of the mucosa. **C:** The histologic diagnosis (t) is suspected because of the hyperintense septal mass and of the several hyperintense plaque-like lesions appearing as bright spots on the nasal mucosa of both sides (*arrowheads*).

(i.e., malignant mucosal melanoma, poorly differentiated carcinoma, sinonasal undifferentiated carcinoma, neuroendocrine carcinoma, high-grade sarcomas, Ewing sarcoma) and advanced-stage malignancies to demonstrate regional or distant metastasis.

Biopsy of the lesion under endoscopic guidance should be performed in a setting where bipolar forceps, a suction system, and hemostatic agents (i.e., cellulose oxidized) are available, especially when imaging studies show a hypervascular mass. In view of the fact that differential diagnosis can frequently be challenging and that tumors present a large necrotic component, an abundant sample of vital tissue should be provided to the pathologist, who often needs immunohistologic or even genetic studies to establish the correct diagnosis. Hence, the practice of obtaining a histologic diagnosis on frozen sections at the time of surgery must be strongly discouraged.

Based on imaging studies and histologic diagnosis, the lesion is classified according to a specific staging system. AJCC system applies to all epithelial and neuroendocrine tumors, but not to soft tissue, bone and cartilage, neuroectodermal, germ cell, or hematolymphoid tumors. Olfactory neuroblastoma is commonly staged according to the Kadish system modified by Morita et al., while for malignant mucosal melanoma a specific classification has been introduced by the AJCC.

SURGICAL TECHNIQUE

Surgery is performed under general endotracheal anesthesia, which is preferably conducted with intravenous agents (propofol and remifentanil). The patient is prepped and draped, with both eyes accessible for inspection. One milliliter of a 5% aqueous sodium fluorescein solution mixed with 9.0 mL of CSF is injected in the subarachnoid space to better disclose an unexpected CSF leak and to verify the water-tight closure of duraplasty when resection is required. Decongestion of both nasal fossae is obtained by positioning cottonoids soaked in 1:10,000 adrenalin.

The use of a navigation system is highly recommended especially in tumors with critical relationships with the anterior skull base, ICA, optic nerve, or cavernous sinus. An ultrasound Doppler probe may be of further help in detecting the ICA, when the tumor extensively erodes the lateral wall of the sphenoid sinus contiguous with the paraclival/cavernous portion of the vessel. Other tools such as a microdebrider with straight and curved blades, a drill with straight and curved burs, specifically designed surgical instruments, and effective hemostatic agents (i.e., Surgicel, Avitene, Floseal, Bovine Thrombin) should be always available.

Variations in the extent of resection (unilateral vs. bilateral; ETR vs. ETRC) are dictated by the pattern of local growth of the tumor; however, even histology has a role. For instance, in olfactory neuroblastoma resection always encompasses the adjacent skull base, dura, olfactory bulb, and tract at least on one side in view of the well-known propensity of this tumor to spread along the olfactory phyla. In intestinal-type adenocarcinoma, there are data suggesting that the entire ethmoid complex should be routinely removed in view of the fact that exposure to wood dust, which is almost invariably associated with this tumor, renders the entire mucosa of the nasoethmoidal complex vulnerable to developing foci of adenocarcinoma.

The goal of endoscopic tumor removal is similar to that of external approaches, namely complete resection with clear histologic margins. The major difference lies in the difficulty for endoscopic resection to be performed with an "en bloc" technique, which has been regarded as a heresy by those who strongly believe in the absolute value of this principle. In fact, only in small lesions can removal be accomplished in a single bloc, while in the vast majority of cases, a technique of progressive disassembly of the tumor going from the inner part of the nasal cavity to the peripheral boundaries is employed (Fig. 19.5).

The intervention typically starts by debulking the tumor, which is performed by powered instrumentation or cutting instruments with the intention of defining the possible site of origin of the lesion and its relationship with the orbit and anterior skull base. This step is crucial, because it frequently provides details about local spread that cannot be identified even by accurate imaging studies and thus helps to guide the surgical strategy (Fig. 19.6). Subsequently, subperichondrial/subperiosteal dissection of the mucosa investing the nasoethmoidal complex is performed (Fig. 19.7), starting medially along the septum at the level of the insertion of the middle turbinate and laterally along the maxillary line and proceeding posteriorly along the lamina papyracea until the sphenoid sinus is reached. The sphenopalatine artery is identified and coagulated. The dissection is superiorly carried at the level of the fovea ethmoidalis and cribriform plate by cutting the olfactory phyla. Posterior sectioning of the mucosa along the anterior wall of the sphenoid sinus at the junction with the choana allows release of the specimen, which incorporates the tumor. Incisions of the nasal mucosa can be performed with electrocautery or any of the available lasers (i.e., diode, CO_2, thulium), to minimize bleeding and therefore to optimize the visualization of the surgical field. When the surgical plan includes resection of the entire nasoethmoidal complex, it is advisable to remove the framework of the septum from the beginning leaving only the most anterior part of the quadrangular cartilage. In this way surgeons can work with a four-handed two-nostril technique. Mucosa investing the nasoethmoid complex on the contralateral side is then resected, a Draf III median sinusotomy is performed to obtain wide access to the entire frontal sinus, and the crista galli is removed to maximize the exposure of dura along the posterior wall of the frontal sinus.

In case of tumors abutting or invading the anterior skull base, resection is extended to include, as a subsequent layer, the dura and the olfactory bulb, either unilaterally or bilaterally according to the extent of the

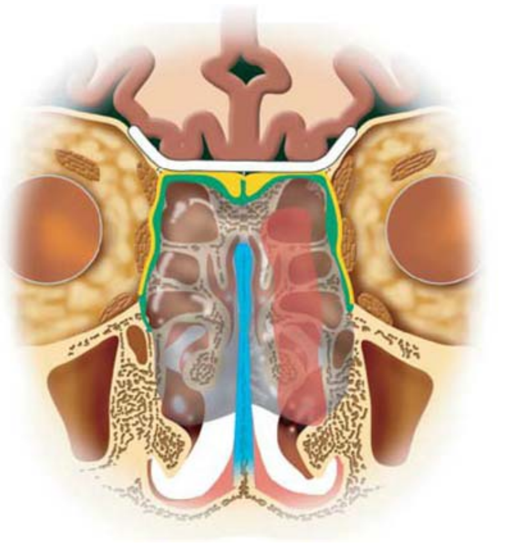
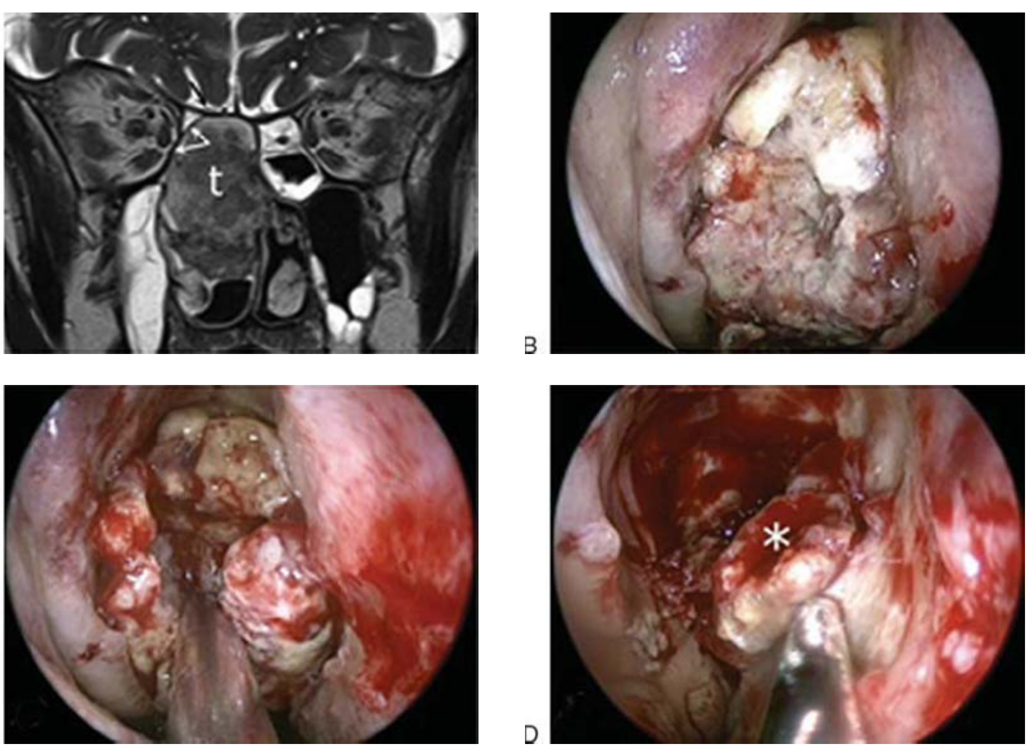


FIGURE 19.5 This drawing in a coronal plane summarizes the concept of tumor disassembling. Starting from the central exophytic component of the tumor, debulking is obtained usually by powered instrumentation (*red*). The nasal septum can be partially removed in order to use a two-nostril four-hand technique (*blue*). The entire ethmoidal box is then dissected along a subperiosteal plane (*violet*). The residual bone is subsequently drilled out (*green*). Dura of the anterior cranial fossa and/or periorbit(s) can be resected (*yellow*) according to tumor extension. The dura is subsequently reconstructed to separate the endocranium from the nasal cavity (*white*).

tumor. In the most extensive bilateral resection, dura is exposed by performing two longitudinal osteotomies with a drill and a Kerrison rongeur at the junction between the roof of the ethmoid and the lamina papyracea on both sides. These osteotomies are then connected by two transverse osteotomies at the level of the planum sphenoidale and at the junction of the posterior wall of the frontal sinus with the roof of the ethmoid (Fig. 19.8). Before entering the subdural space, the dura is dissected over the orbital roof(s) laterally (Fig. 19.9), the planum sphenoidale posteriorly, and the posterior wall of the frontal sinus anteriorly to make duraplasty easier. A rectangular area of dura matching the osteotomies and far enough from the tumor borders is resected together with olfactory bulbs and tracts. Frozen sections are obtained from the residual dura and olfactory tracts to assess the completeness of the resection (Fig. 19.10).



A B C D

FIGURE 19.6 **A:** Epithelial–myoepithelial carcinoma of the right nasal cavity in a 77-year-old man. In the coronal T2-weighted plane, the tumor is shielded from the orbital and the intracranial contents by the bone, which appears homogeneously hypointense (The *white arrows* indicate the displaced wall of a posterior ethmoid cell; right olfactory tract: *black arrow*). However, imaging does not clarify whether the tumor invades or is simply in contact with the mucosa of the olfactory niche. **B:** Endoscopic appearance of the lesion at the beginning of the procedure. **C,D:** The lesion is gradually debulked starting from the core in order to clearly identify its site of origin, which is located at the level of the sphenoid rostrum (*white asterisk*).

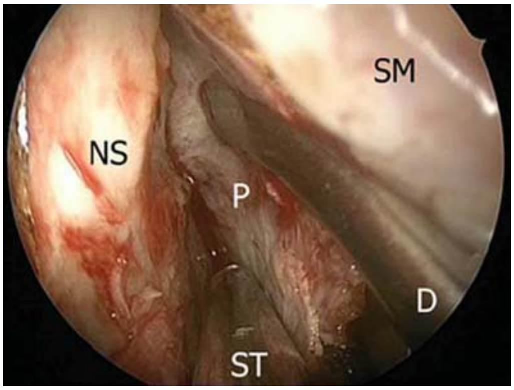


FIGURE 19.7
Subperiosteal dissection of the left nasal fossa. Septal mucosa (SM) is elevated from the cartilaginous/bony nasal septum (NS) in a plane deep to the periosteum (P) with the help of a dissector (D) and suction tip (ST).

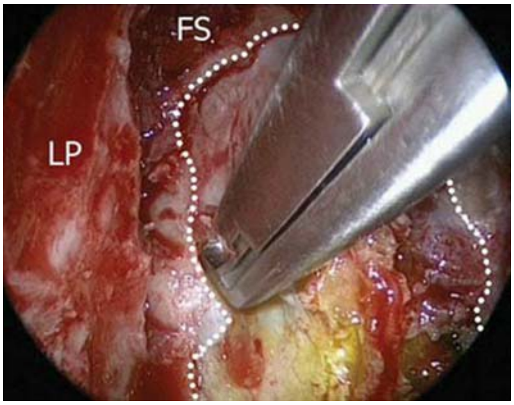


FIGURE 19.8
The osteotomies obtained with a diamond drill are ultimately refined by using a Kerrison rongeur, paying attention to keep the dural layer intact. The *white dotted line* defines the limits of the resection at the level of the anterior skull base. FS, frontal sinus; LP, lamina papyracea.

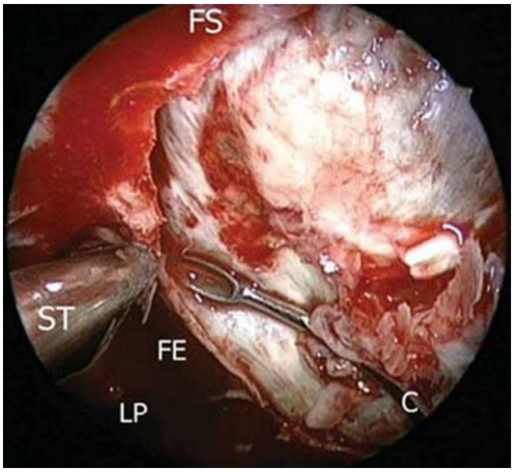


FIGURE 19.9
Once craniectomy is completed, dura needs to be elevated from the adjacent skull base by blunt dissection before opening and resecting it. FS, frontal sinus; C, curette; ST, suction tip; FE, fovea ethmoidalis; LP, lamina papyracea.

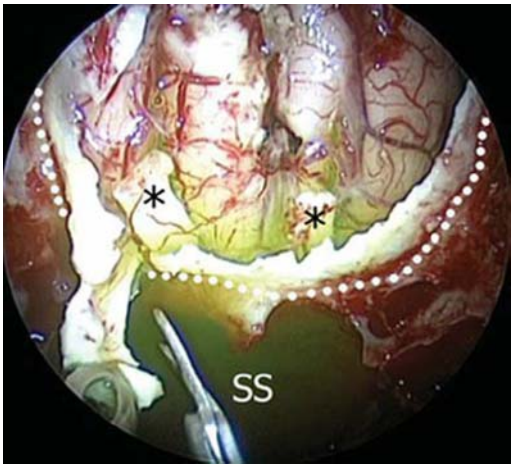


FIGURE 19.10
Posterior aspect of the skull base and dural defect after bilateral craniectomy. The posterior resection margin is checked by frozen sections. The olfactory bulbs have been resected, and both olfactory tracts are visible (*black asterisk*). The *white dotted line* defines the limits of the resection at the level of the anterior skull base. SS, sphenoid sinus.

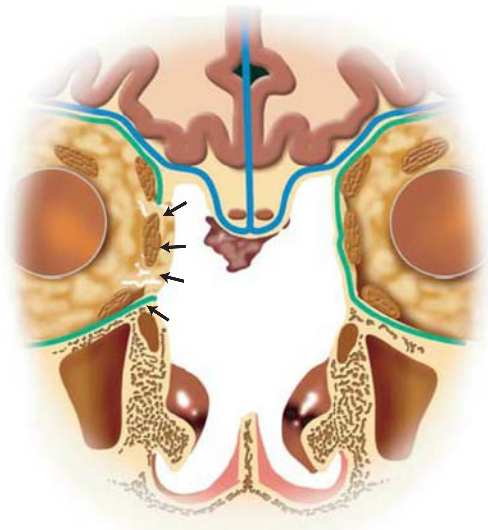


FIGURE 19.11 This drawing on a coronal plane shows the endonasal prolapse of the orbital content (*black arrows*) in the case of resection of the periorbita.

Similarly, when the lesion has eroded the lamina papyracea in part or completely and is in close contact with the periorbita but there are no signs of invasion of the soft tissues of the orbit on MR, the periorbita should be carefully explored. In the vast majority of cases, the tumor is simply in contact but no clear signs of adhesion/invasion are visible. Nonetheless, it is advisable to resect the adjacent periorbita (Fig. 19.11) and send it for definitive pathologic examination. An intraoperative finding of growth of the lesion through the periorbita not anticipated by MR is extraordinarily rare.

After an extensive resection of the dura, the surgeon is faced with a large defect in the anterior skull base (Fig. 19.12), which needs to be repaired in order to separate the endocranium from the sinonasal cavities. In recent years, several pedicled flaps have been described with the intent to provide vascularized tissue for sealing the dural defect and minimize complications. In this specific setting, many are unsuitable for reasons related to the limited size or the inadequate arc of rotation, or they are not available because of tumor resection. Thus, the choice is left among a transfrontal pericranial flap, transpterygoid temporoparietal fascia flap, and, in some selected cases of unilateral removal, a nasoseptal flap. A pedicled flap is typically used as a second layer after the defect has been closed with dural graft matrix. My preference for many years has been the iliotibial tract, which is a continuation of the fascia lata at the lateral aspect of the thigh extending from the iliac crest to the infracondylar tubercle of the tibia because of its ideal thickness, pliability, and strength. A graft together with subcutaneous adipose tissue, commonly 10 × 6 cm in size, is harvested in the middle third of the thigh through a longitudinal skin incision. The plasty is performed in a "three-layer" fashion (Fig. 19.13). For the first, intradural layer, the graft is oversized 30% larger than the dural defect and split anteriorly in the midline to adjust to the residual part of the falx cerebri in bilateral resection. The second layer, intracranial and extradural, needs to

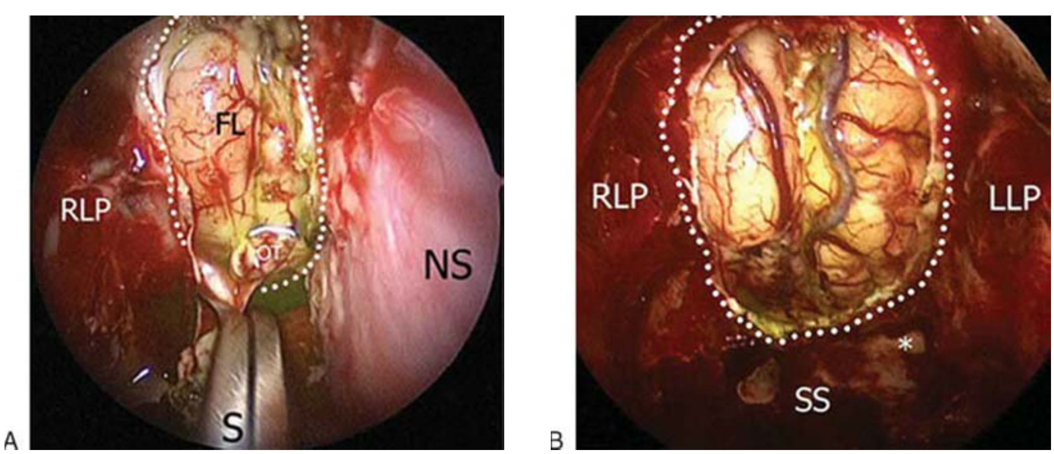


FIGURE 19.12 Endoscopic appearance of the surgical field at the end of a unilateral **(A)** or bilateral **(B)** craniectomy before dural reconstruction The *white dotted lines* define the limits of the resection at the level of the anterior skull base, and the *white asterisk* in figure **(B)** indicates the left optic nerve in the sphenoid sinus (SS). RLP, right lamina papyracea; LLP, left lamina papyracea; NS, nasal septum; S, scissor; FL, frontal lobe; NS, nasal septum; OT, olfactory tract.

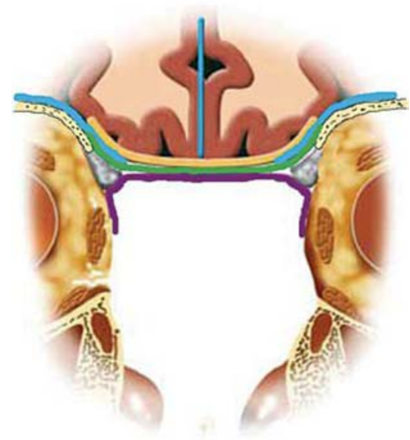


FIGURE 19.13 The drawing in a coronal plane shows the relationship of the three layers of the iliotibial tract in relation with the dura (*blue*) and residual skull base (*pink*). The first layer (*yellow*) is positioned in the intradural compartment, the second (*green*) between the dura and the residual skull base, and the third (*violet*) overlay in the nasal compartment. Fragments of adipose tissue can be used along the borders to refine sealing of the duraplasty (*grey*).

be precisely sized and tacked between the previously undermined dura and residual anterior skull base. Pieces of adipose tissue are used to eliminate the dead space between the second and third layers and to flatten the residual denuded anterior skull base. The third extracranial layer should cover all of the exposed bone, but not overlapping the frontal sinusotomy. Each layer is properly fixed at the periphery with a small amount of fibrin glue. At the end of the procedure, the frontal sinus is stented with rolled Silastic sheath(s) to allow subsequent frontal sinus debridement with no risks to the duraplasty. Stent(s) are kept in place for 4 weeks or up to the end of adjuvant radiotherapy, when indicated. A light nasal packing including two finger gloves in each nasal fossa filled with a Lyofoam (Seton Health Care Group, Oldham, UK) sponge is inserted. Lumbar drainage is typically not used.

POSTOPERATIVE MANAGEMENT

When the dura has not been resected, antibiotic therapy is commonly not administered and the patient is discharged on the first postoperative day after removing the nasal packing, if present. Whenever duraplasty is performed, CT of the brain is performed 24 hours after surgery to look for any possible intracranial complication (minimal residual pneumocephalus is a common finding), the patient is kept in bed for 48 hours with the head elevated at 15 degrees, antitussive and antiemetic agents are given to prevent the increase of intracranial pressure and consequently the possible occurrence of CSF leak, and a broad spectrum intravenous antibiotic is administered from the day before surgery until the day after the nasal packing is removed, which is typically 2 days after surgery. At this time, the nasal cavities are inspected with the help of a rigid endoscope to gently remove blood clots and to exclude the presence of CSF leak. Oral feeding is resumed, and the patient is allowed out of bed.

COMPLICATIONS

The extent of surgery (extradural or transdural) affects the occurrence of complications in terms of both frequency and severity. Overall, only a few patients are exposed in the perioperative period to the risk of minor complications, as epistaxis, which can be managed in an ambulatory setting, or ecchymosis of the eyelids and long-term sequelae, which include synechiae, mucocele (of the frontal or sphenoid sinus) due to scar closure of a sinusotomy, and a complete stenosis of the lacrimal apparatus with epiphora, when the nasolacrimal duct was resected.

Not unexpectedly, in patients undergoing resection of the dura, the most frequent major complication is CSF leak. In our experience, this problem has decreased considerably in relation to the refinement of the reconstructive technique and the use of autologous material. A diagnosis of CSF leak is commonly made when nasal packing is removed or in the following 24 to 48 hours. Endoscopic inspection allows establishing whether a minor revision even under local anesthesia with sedation can be performed or a redo duraplasty is required. Even in these circumstances, placement of a lumbar drain is commonly avoided.

The occurrence of a more serious complication, hypertensive pneumocephalus, is rarely observed (Fig. 19.14). The diagnosis of this condition, which should be suspected when the patient presents with headache, nausea and vomiting, and impairment of neurologic status, is confirmed by CT of the brain. Immediate revision duraplasty is required; tracheostomy may be indicated to minimize the chance of a second failure.

FIGURE 19.14 Tension pneumocephalus occurring on the second postoperative day after ECRT in a 79-year-old man with intestinal-type adenocarcinoma of the ethmoid sinus. CT shows a bilateral subdural collection of air (*double arrows*) exerting mass effect on the frontal, parietal lobes, and lateral ventricles (*arrows*).

RESULTS

The major points of criticism of the data reported in the literature regarding endoscopic treatment of sinonasal malignancies concern the short follow-up time, limited number of patients, the fact that most series grouped different histologies together, and the variable use of adjuvant radiotherapy. Length of follow-up is indeed a crucial issue particularly in some histologies such as olfactory neuroblastoma and adenocarcinoma, which can be associated with late local recurrences, occurring well beyond a 5-year period. The two largest series, reporting on 184 and 120 patients collected at two tertiary Italian centers over a 10-year span and at the MD Anderson Cancer Center in Houston over a 16-year period, respectively, included different histologies. Furthermore, approximately one-fourth of cases in both series had undergone surgery consisting of a combined endoscopic–transcranial approach.

Notwithstanding these limitations and the variable prevalence of histologies in the two series, with adenocarcinoma and olfactory neuroblastoma being the most frequent in the Italian and US experience, respectively, the 5-year disease-specific survival (DSS) for the entire patient cohort was quite similar (81.9% vs. 87%), with no major difference in the mean follow-up (34.1 vs. 37 months). Not unexpectedly, our group found a statistically significant difference in 5-year DSS between patients treated with endoscopic surgery alone compared to those who received endoscopic transcranial resection (91.4% vs. 58.8%; $P < 0.001$), an observation that was not confirmed by Hanna et al. As pointed out by these authors, this variability may reflect different criteria used for patient selection for the different approaches, with the US group being more inclined to reserve an endoscopic approach for patients with relatively earlier disease stage and no or limited skull base invasion. More recently (unpublished data), we updated the analysis of our series of patients, which includes 265 patients treated by a purely endoscopic approach (ETR = 139; ETRC = 126), with a minimum follow-up of 12 months. There was no statistically significant difference in 5-year DSS between the two subgroups (ETR = 86.2%; ETRC = 85.7%). Histology, however, had a significant impact on 5-year DSS: 100% in olfactory neuroblastoma, 86.7% in adenocarcinoma, 50.7% in the carcinoma group, and 20.4% in melanoma.

Most publications analyzing the efficacy of endoscopic surgery in a specific histology have concentrated on olfactory neuroblastoma reported the results of a multicenter study performed at two US centers on 23 patients (10.5% were modified Kadish stage A, 58.9% stage B, 26.3% stage C, and 5.3% stage D). All but one patient, who required the association with a transcranial approach to obtain a positive margin along the supraorbital dura, had the tumor resected endoscopically. Postoperative radiotherapy was delivered in 16 patients. After a mean follow-up of 45.2 months, all patients were free of disease at the primary site.

The outcome of endoscopic surgery followed by radiotherapy in adenocarcinoma has been reported by Van Gerven et al. in a series of 44 patients, including 1 T1, 26 T2, 5 T3, 9 T4a for sphenoid sinus involvement, and 3 T4b for limited dural involvement. Median follow-up was 61 months. Of note, if the tumor was unilateral no contralateral dissection was undertaken and the resection was rarely extended to include the dural plane. Sixteen (36%) patients experienced local recurrence, which was diagnosed within 24 months of primary treatment in nine cases. Retreatment included a second endoscopic procedure in nine and craniofacial resection in three patients. Five-year DSS was 82% and was significantly influenced by recurrence but not by T category. In view of the observation of local recurrences in areas that were quite different from the initial presentation, the authors considered the opportunity to include the entire ethmoid labyrinth in the resection. Another experience

on a small number ($n = 12$) of patients with adenocarcinoma (6 T2, 5 T3, and 1 T4) was associated with a 91.6% 5-year disease-free survival after a median follow-up of 30 months.

A recent systematic review with a pooled-data analysis comparing the outcome of endoscopic versus craniofacial resection in a group of 226 patients, where olfactory neuroblastoma, adenocarcinoma, and undifferentiated carcinoma were the most frequent histologies, yielded interesting results. Among low-stage malignancies (T1-2 or Kadish A-B), the endoscopic and open approaches demonstrated no statistically significant difference. Five-year DSS survival was 94.7% in the first group, and 87.7% in the second. According to the authors, endoscopic management of high-stage cancers has been reported less frequently, making it difficult to elicit adequate statistical analysis. Devaiah and Andreoli (2009) performed a meta-analysis on 379 patients treated for olfactory neuroblastoma. Although endoscopic surgery yielded statistically significant better survival rates than open surgery, these results must be interpreted with caution based on the differences in follow-up times and Kadish stage distribution between the two groups.

PEARLS

- Treatment planning is based on imaging studies and histologic diagnosis.
- The aim of endoscopic surgery is to achieve complete resection of the tumor with clear margins as in traditional external approaches.
- When involvement of the cribriform plate/fovea ethmoidalis is pre- or intraoperatively assessed, resection must include the anterior skull base, and the olfactory bulb and tract, uni- or bilaterally, according to the size and histology of the tumor.
- Since en bloc resection is rarely feasible, the specimen is removed layer by layer by progressively moving from the inner part of the nasal cavity to the periphery.
- Reconstruction of the dural defect can be performed with a multilayer technique, using grafts of iliotibial tract or a combination of Alloderm and a pedicled pericranial flap.
- When compared with traditional techniques, endoscopic resection is associated with decreased hospitalization time and morbidity and better cosmetic results.
- Although the experience in the literature is mostly based on retrospective case series studies, data suggest that in early-stage tumors endoscopic resection is a viable alternative to external approaches.

PITFALLS

- Endoscopic surgery for sinonasal malignancies should be performed only after the surgeon has acquired large experience in the treatment of inflammatory diseases and benign tumors.
- There are tumors with critical anatomic extent where endoscopic surgery is contraindicated in view of the impossibility to achieve radical removal or to close the dural defect.
- In spite of the refinement in the surgical repair of dural defects, complications such as CSF leak, pneumocephalus, and meningitis can still occur.
- Experience in the endoscopic management of advanced-stage lesions is too limited in terms of the number of patients and length of follow-up to definitively establish its value.

INSTRUMENTS TO HAVE AVAILABLE

- Endoscopes (0, 45, and 70 degrees)
- A complete set of instruments for standard endoscopic sinus surgery, including through-cutting forceps
- Beaver blade
- Kerrison rongeurs
- Straight and curved microscissors for dura
- Electrocautery specific for endonasal surgery
- Bipolar forceps
- Microdebrider with straight and curved blades
- Straight and angled endoscopic drill with different-sized diamond and cutting burrs
- Lens irrigation system for endoscopes
- Navigation system

ACKNOWLEDGMENTS

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20 ORBITAL EXENTERATION

Bita Esmaeli

INTRODUCTION

Orbital exenteration is the surgical removal of the contents of the orbit and the periorbital soft tissue, including the eye, extraocular muscles, optic nerve, periorbita, orbital adipose tissue, eyelids, and periorbital skin. The most common indication for orbital exenteration is a malignancy of the eye, orbit, ocular adnexa, or periocular region for which salvage of the globe is not possible. In some cases, not only the orbital and periorbital soft tissue but also the bony orbital walls must be removed.

HISTORY

Orbital exenteration not only results in loss of the eye and its function but also causes significant facial disfigurement. Thus, this procedure should be reserved for patients in whom salvage of the globe is not possible because of the very aggressive nature of the malignancy and the need for wide margin of resection. In most instances, orbital exenteration is only appropriate for patients in whom the possibility of cure is likely enough to justify this radical procedure.

Given the dramatic changes in function and appearance caused by orbital exenteration, counseling of the patient prior to surgery is essential. Proper presurgical counseling and understanding of the patient's expectations are important to minimize the patient's distress. During the preoperative interview, the patient's past medical and surgical history, current medications, coagulation status, and allergies should be ascertained. There should also be a review of systems focusing on symptoms or signs of cancer metastasis, which would be a relative contraindication to the procedure.

PHYSICAL EXAMINATION

During the physical examination in a patient being considered for orbital exenteration, the tumor should be carefully evaluated, and its exact location within the orbit, ocular adnexal structures, paranasal sinuses, or nasal cavity should be noted. This information is used to plan the skin incision and to decide which other adjacent periorbital structures to include in the resection, if indicated. When an "eyelid-sparing" orbital exenteration may be possible, the skin of the upper and lower eyelids should be carefully examined, and the degree of laxity and redundant skin should be noted as this skin will be used to line the orbit.

INDICATIONS

The indications for orbital exenteration can be divided into four general categories: tumors of the eyelid or conjunctiva for which salvage of the globe is not possible, intraocular tumors with extension to the orbital soft

tissue, orbital extension of tumors of the paranasal sinuses or nasal cavity, and orbital extension from intracranial processes.

Orbital exenteration can be required for treatment of squamous cell carcinoma, basal cell carcinoma, sebaceous carcinoma, conjunctival melanoma, uveal melanoma with extrascleral or orbital extension, epithelial cancers such as adenoid cystic carcinoma of the lacrimal gland, rhabdomyosarcoma, and other rare sarcomas.

Orbital exenteration may also be indicated for certain nonmalignant neoplasms, such as neurofibromatosis causing severe orbital displacement, immobility, and blindness or extensive lymphangioma causing disfigurement or orbital pain. Finally, inflammatory or infectious processes associated with refractory orbital pain (e.g., invasive fungal infections such as mucormycosis) may be indications for orbital exenteration.

CONTRAINDICATIONS

Orbital exenteration may not be appropriate in patients with widespread metastatic disease, patients with tumors expected to have a high likelihood of local–regional recurrence despite orbital exenteration, elderly patients with multiple medical comorbidities, or patients with a short life expectancy. For such patients, palliative radiation therapy, other palliative medical treatments, or various degrees of debulking may offer a better quality of life than orbital exenteration.

PREOPERATIVE PLANNING

Imaging studies such as computed tomography (CT) or magnetic resonance imaging (MRI) of the orbit are an integral part of the preoperative evaluation and provide information about the gross anatomic extent of the cancer. For example, if there is extension of cancer into the paranasal sinuses or nasal cavity, a multidisciplinary approach may be more appropriate. Involvement of bony walls of the orbit on CT would help plan the appropriate bony resection and reconstruction. Or, if there is deeper orbital extension based on CT or MRI, a deeper orbital exenteration may be planned. A careful examination for signs of local or regional disease spread is essential because orbital exenteration may not be appropriate in patients with regional lymph node or distant-organ metastasis. The evaluation for systemic disease should be tailored to the type of cancer.

Because general endotracheal anesthesia is necessary for orbital exenteration, a preoperative anesthesiology consultation is important to rule out any cardiac or pulmonary contraindications to general anesthesia.

It is also important to discuss with the patient the types of reconstructive procedures available and to find out whether the patient is interested in wearing an orbital prosthesis, as this may affect the choice of reconstructive procedures. Whether postoperative adjuvant radiation therapy will be needed should be taken into account in surgical planning as the need for radiation therapy impacts the choice of tissue coverage for the orbital cavity.

SURGICAL TECHNIQUE

Orbital Exenteration

The first step of the orbital exenteration procedure is outlining of the skin incision on the upper and lower eyelids. The skin incision is designed to create an adequate disease-free margin around the tumor. Lidocaine 1% with epinephrine (1:100,000) is infiltrated along the incision line and into the anterior orbital soft tissue. It is very important to warn the anesthesiologist about the risk of bradycardia due to oculocardiac reflex from manipulation of the extraocular muscles during this procedure. The skin incision is made using a 15 blade. A monopolar electrocautery using a needle tip is used to carry the dissection down to the orbital rim, and then the periosteum is incised. With a periosteal elevator, the periosteum is dissected away from orbital bone posteriorly toward the orbital apex. When there is firm attachment of periosteum to orbital walls—for example, in the area of the orbital fissures, lateral tubercle, or medial canthal tendon insertion—the periosteum may have to be incised with electrocautery. The nasolacrimal duct is transected just distal to the lacrimal sac using electrocautery. Care is taken not to violate the orbital walls adjacent to the paranasal sinuses, especially medially and inferiorly, where they are thin, to avoid creating a sino-orbital fistula. Bipolar electrocautery is used to maintain hemostasis and for cautery of all major blood vessels. Once adequate dissection is accomplished to the apex of the orbit, a curved clamp is used on the orbital contents at the apex. Heavy scissors are used to cut the orbital contents within the periorbita just above the clamp. Further hemostasis is achieved at the orbital apex using bipolar cautery. The specimen is clearly oriented with placement of sutures and is taken to the pathology laboratory for frozen section evaluation of margins of interest. Alternatively, additional specimens from the tissue surrounding the surgical defect and from the orbital apex can be submitted for frozen section evaluation.

The orbital cavity is inspected for any residual disease that may require further excision and then packed with Cottonoid or gauze soaked with thrombin. Any remaining bleeding can be controlled with bipolar cautery or, in the case of bone-perforating vessels, with bone wax.

Eyelid-Sparing Orbital Exenteration

Eyelid-sparing orbital exenteration may be appropriate for cancer involving the bulbar conjunctiva or limited to the palpebral conjunctiva or soft tissue in the anterior orbit. This modification of the standard orbital exenteration technique spares the skin and orbicularis layer of the eyelid.

In an eyelid-sparing procedure, the skin incision is made a few millimeters superior to the upper eyelid lash line and a few millimeters below the lower eyelid lash line. After the skin incision is made, a plane of dissection is established between the skin and orbicularis muscle with blunt-tipped scissors to the orbital rim. Scalpel or electrocautery is used to deepen the incision to the periosteum. From this point, the procedure is carried out like standard exenteration. Once hemostasis is achieved, the skin flaps from the preserved upper and lower eyelid skin are sutured to each other.

In the case of deep orbital exenteration with the orbital contents removed to the apex, an eyelid-sparing orbital exenteration is not appropriate because there may not be enough eyelid skin to adequately resurface the orbital cavity.

Orbital Exenteration Plus Removal of One or More of the Orbital Bony Walls

Sometimes orbital exenteration must be combined with removal of bony walls of the orbit. The most common indication for such surgery is a tumor of the paranasal sinuses or nasal cavity that secondarily involves the orbital bony walls and the orbital soft tissue. Other indications are primary orbital tumors with a high propensity for spread to the orbital bony walls—for example, adenoid cystic carcinoma of the lacrimal gland (Fig. 20.1).

Once the surgical specimen has been removed, the surgeon must orient the pathologist to the orbital contents, the location of the tumor in the orbit, and the margins of interest that should be subjected to frozen section evaluation or embedded in paraffin for later examination. The globe (eyeball) is formalin fixed for several days before it is sectioned. Depending on the underlying cancer diagnosis, the various ocular and orbital structures can be histologically evaluated. If the bony walls of the orbit are included in the specimen, the pathologist should be alerted to arrange for decalcification and evaluation of the bony pieces.

Reconstruction of the Orbital Cavity

The primary goal of reconstruction of the orbital cavity is to provide durable coverage of the orbit and, if the defect has a cranial, sinus, or nasal cavity extension, the brain, paranasal sinuses, or nasal cavity. In patients with aggressive cancer, the reconstructed orbital cavity also has to be able to withstand postoperative adjuvant high-dose radiation therapy. Ideally, the reconstructed orbital cavity should also accommodate an orbital prosthesis if the patient desires one. A number of reconstructive methods have been described that attempt to fulfill these goals.

The main determinants of which reconstructive options are available are the extent of the orbital defect and whether the patient plans to use an orbital prosthesis. When an open (concave) cavity is desired to allow for future fitting of an orbital prosthesis, when there is no need to isolate the orbital cavity from the sinonasal, oral, or intracranial cavities, and when there is no anticipated need for postoperative radiation therapy, split- or full-thickness skin grafts would be very reasonable choices (Fig. 20.2A). However, vascularized regional pedicled flaps (temporoparietal fascial flap or temporalis muscle flap, Fig. 20.2B) or various types of microvascular free flaps (Fig. 20.2C and D) are appropriate when orbital exenteration is combined with removal of the orbital bony walls, when orbital exenteration is combined with removal of paranasal sinuses, when high-dose postoperative radiation therapy is planned, or when the patient has already undergone irradiation of the orbital area. Vascularized flaps decrease the likelihood of osteoradionecrosis or skin breakdown after radiation therapy. However,

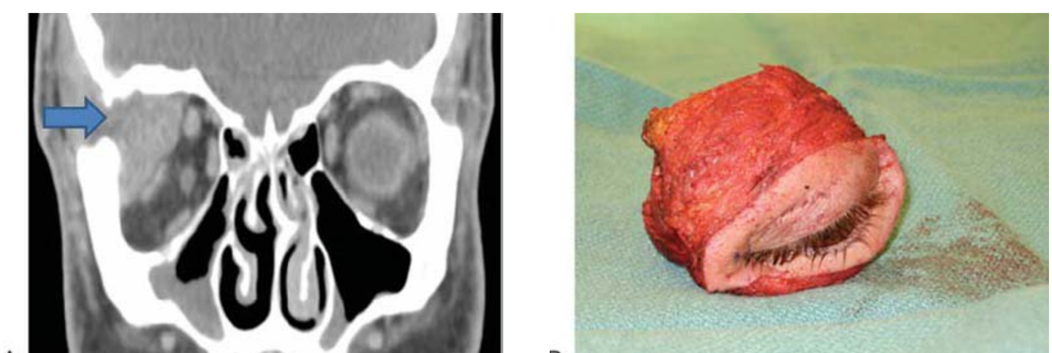

FIGURE 20.1 **A:** CT in a patient with carcinoma of the lacrimal gland with involvement of the lateral wall of the orbit (*arrow*). **B:** orbital exenteration specimen includes en bloc excision of the superolateral bony walls.

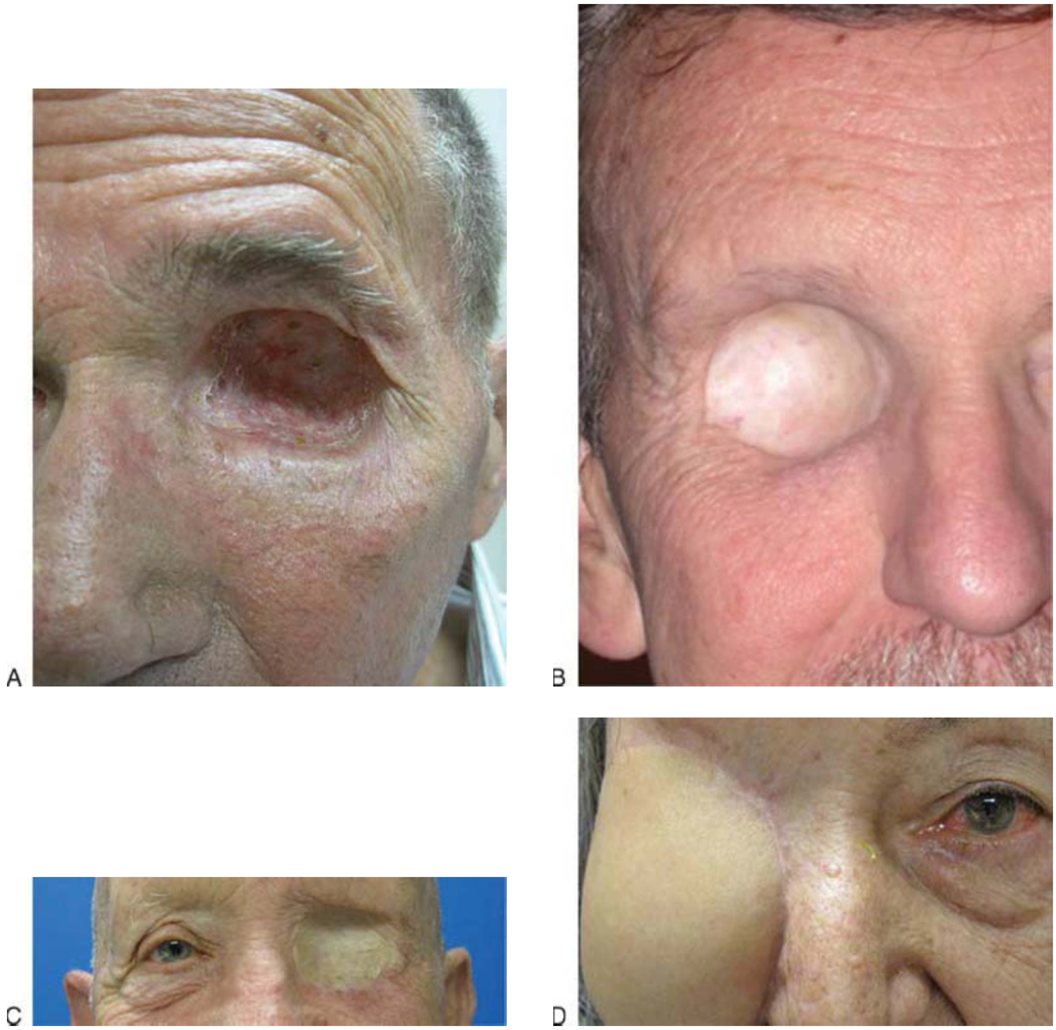

FIGURE 20.2
Orbital exenteration cavity lined with **(A)** a full-thickness skin graft, **(B)** a temporoparietal fascia flap covered by a skin graft, **(C)** a radial forearm flap, and **(D)** an anterior thigh flap.

free flap reconstruction after exenteration is associated with a lower success rate for orbital prosthesis wear compared with reconstruction based on full-thickness or split-thickness skin grafts or regional flaps; this is particularly true with the larger free flaps (Fig. 20.2D). Microvascular free flaps are also associated with longer length of surgery, the need for hospital admission and intensive care monitoring, and associated donor-site morbidities. Another relative disadvantage of free flaps may be the inability to fully inspect the orbital cavity after reconstruction with complex bulky flaps. An immediate postoperative baseline imaging study may facilitate monitoring of the orbital area for cancer recurrence. Regional flaps such as temporalis muscle or fascia flaps are compatible with good prosthesis fit but are associated with the minor disadvantage of donor-site bony depression in the temple.

Another option is to allow the orbital cavity to fill with granulation tissue and heal by secondary intention. During healing, which usually takes at least 8 to 12 weeks, daily wound care consisting of irrigation with 2% hydrogen peroxide and wet-to-dry dressings is needed.

POSTOPERATIVE MANAGEMENT

In patients who undergo reconstruction with free flaps, the flap is monitored intensely for 5 to 7 days after exenteration while the patient is hospitalized.

Patients who have the orbital cavity lined with a skin graft and patients who undergo eyelid-sparing orbital exenteration are usually observed in the hospital for 24 hours. The socket is covered with a pressure dressing for 5 days. On the fifth postoperative day, the pressure dressing is removed. Patients are treated with oral antibiotics for 7 days, and topical antibiotic ointment is applied to the orbital socket for 3 weeks postoperatively or until the surgical site is fully healed and epithelialized.

In all patients who undergo orbital exenteration, protection of the remaining eye is a top priority. Monocular precautions should be stressed.

FIGURE 20.3 Orbital prosthesis in the patient depicted in Figure 20.2B.

Orbital Prosthesis

In patients who do not wish to wear an orbital prosthesis, an eye patch can be used to cover the orbital defect. In patients who do wish to wear an orbital prosthesis, the type of reconstruction chosen for the orbital cavity and patient motivation are the major factors determining whether an orbital prosthesis can be successfully fitted. Oculofacial prostheses custom-made of polymethylmethacrylate can restore considerable facial symmetry (Fig. 20.3). Osteo-integrated oculofacial prostheses secured to previously implanted magnetic anchors offer better stability and can obviate the need to glue the prosthesis to the surrounding skin.

POSTOPERATIVE COMPLICATIONS

The most common complications after orbital exenteration are skin graft failure or partial slough, infections of the orbital cavity or donor site, sino-orbital fistula, donor-site morbidities, and inability to wear a prosthesis in the reconstructed orbit.

PEARLS

- Knowledge of anatomy is key in identifying blood vessels and nerves preventing significant blood loss or sensory loss.
- Preoperative imaging studies help delineate the posterior extent of exenteration or the need for addition of other procedures such as maxillectomy/ethmoidectomy.
- If high-dose radiation is planned or if large areas of paranasal sinuses or nasal cavity are exposed, vascularized flaps such as free flaps are better suited than skin grafts to cover the orbital socket.
- Prepare the patient for the change in appearance in addition to the loss of function of the eye.

PITFALLS

- Don't forget to alert the pathologist if bony walls of orbit are included in the surgical specimen (need to be decalcified).
- Don't forget to warn the anesthesiologist about oculocardiac reflex, which can cause sudden bradycardia or even total asystole during the procedure.

Psychosocial Considerations After Orbital Exenteration

Many patients who undergo orbital exenteration experience social and psychological problems because of their facial disfigurement. Not only patients but also their family members should be warned about possible difficulties when interacting in large social groups, which may create uncomfortable situations for the patient. Patients should be referred to professionals with special sensitivity to these issues for counseling prior to and after an orbital exenteration. Additional education of physicians, other health care providers, and family members may help lessen this problem at various levels.

INSTRUMENTS TO HAVE AVAILABLE

- A standard eyelid and orbital tray
- The monopolar needle cautery
- Bipolar cautery
- A pair of large scissors is needed to cut the muscle stumps.
- Thrombin-soaked gel foam is helpful to decrease bleeding at the orbital apex.
- 4-0 silk sutures can be used for traction.

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21 RHINECTOMY

Fernando Luiz Dias

INTRODUCTION

The nose challenges the oncologic and reconstructive surgeon with special difficulties related to its central location on the face and its complex three-dimensional architecture. The prominent position of the nose accounts for its constant exposure to sunlight and thus for its predisposition to the development of cancer of the skin. The nose is the most common site of involvement of cancer of the skin, and it is also the most common site of recurrence. Rhinectomy is defined as the removal of the vast majority of the nasal framework, soft tissues, and skin. It is a relatively uncommon procedure with most published series including small numbers of patients managed with a three-dimensional nasal resection for cancers of the skin. The multiple factors that make the cancer of the nose an area at increased risk for aggressive behavior and high recurrence include:

Increased actinic exposure

Relative lack of subcutaneous tissue

Enhanced access to perichondrium and periosteum

Close proximity of embryologic fusion planes

Overly conservative treatment (in order to avoid cosmetic deformity)

Complex three-dimensional architecture

Multicentricity of cutaneous malignancy

HISTORY

Nasal swelling and the presence of an external nasal lesion are the most frequent presenting signs or symptoms. An obvious tumor mass, pain, and nasal obstruction are also common. Other symptoms included epistaxis, inflammation, foul odor, purulent discharge, rhinorrhea, headache, nasal septal perforation, epiphora, nasal collapse, threatened loss of vision, and poor fit of dentures.

PHYSICAL EXAMINATION

Although the clinical characteristics of an advanced cancer of the nose are usually obvious under observation, a careful bimanual palpation is advisable in order to evaluate the involvement of the upper lip, columella, and floor of the nasal cavity (Fig. 21.1A). Endoscopic evaluation of the nasal cavity is crucial in accurate clinical assessment of an intranasal lesion. Despite the low incidence of lymph node metastases found in most

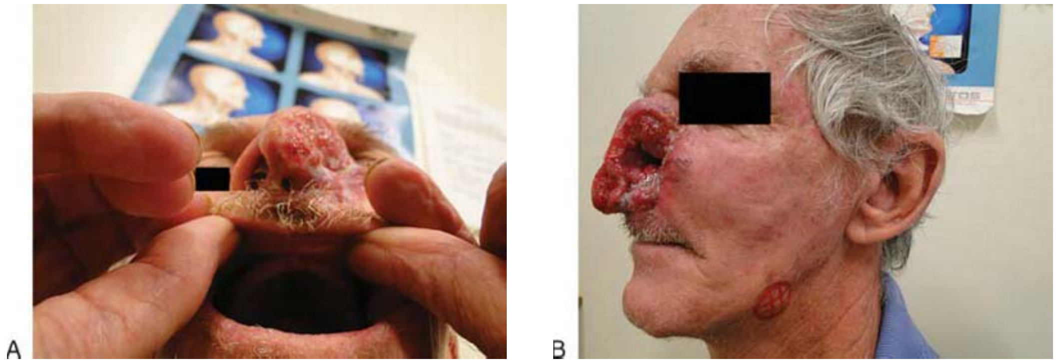

FIGURE 21.1
A: Squamous cell carcinoma of the nose with involvement of the upper lip and gingivobuccal sulcus. **B:** Lymph node metastases from cutaneous nasal SCC.

published series, even in patients with other histologic types than basal cell carcinoma, a careful palpation of the facial, periparotid, and cervical lymph nodes (particularly levels I and II) is advisable (Fig. 21.1B).

INDICATIONS

The local spread of cancer of the facial skin appears to be markedly influenced by embryologic fusion planes as well as the surrounding facial structures. These fusion planes tend to set up individual areas in which cancer of the skin appears to spread rapidly, invading deeply before continuing its superficial spread that would cross a fusion plane. Soft tissue invasion of these neighboring regions may eventually lead to bone or nerve involvement, making tumor eradication much more difficult.

Five anatomical areas of the midface exist in which there is a rather constant reproducible type of spread of cancer. Cancers located over the supratip and columella tend to invade into the nose along the septum with the later site contributing to invasion of the superior aspect of the midlip and premaxilla. Lesions located along the lateral aspect of the nose tend to spread in a caudal–cephalic manner with through-and-through defects occurring along the nares. Cancers of the skin originating in the nasolabial fold tend to invade deeply toward the pyriform aperture and the nasal cavity before spreading on the cheek and lateral aspect of the upper lip. Cancers located in the glabella and root of the nose are prone to invade deeply and laterally toward the medial canthi. Cancers of the skin of the cheek tend to spread in a uniform nature from their central foci extending into the lower eyelid and upper lip while avoiding nasal involvement.

The columella appears to be a particularly high-risk site; cancers at this site have been described by many authors as a "potential time bomb." Such tumors may extend directly along the septal cartilage, posteriorly into the nasal cavity, inferiorly into the maxilla, and superiorly into the anterior skull base, meaning that recurrence is often detected late and is extremely difficult to treat. In addition to that, it is the region of the nose most prone to develop lymph node metastases (Fig. 21.2A and B).

The nasal vestibule is studied separately from other sites of the nose, because it is considered part of the nasal cavity. Carcinomas restricted to the nasal cavity are uncommon accounting for only 20% of all cancers arising in the paranasal sinuses and nasal cavity. The nasal vestibule is also considered the subsite in the nasal cavity that is least often affected by cancer, with most cancers arising from the turbinates. Other subsites affected in descending order of frequency are the nasal septum and floor of the nose. Carcinomas of the vestibule are usually of low histologic grade and demonstrate a relatively low metastatic potential. Lymphatic spread, when occurs, does to the facial and parotid lymph nodes first, before they reach levels I and II. Only 40% of the patients with positive nodes ultimately survive.

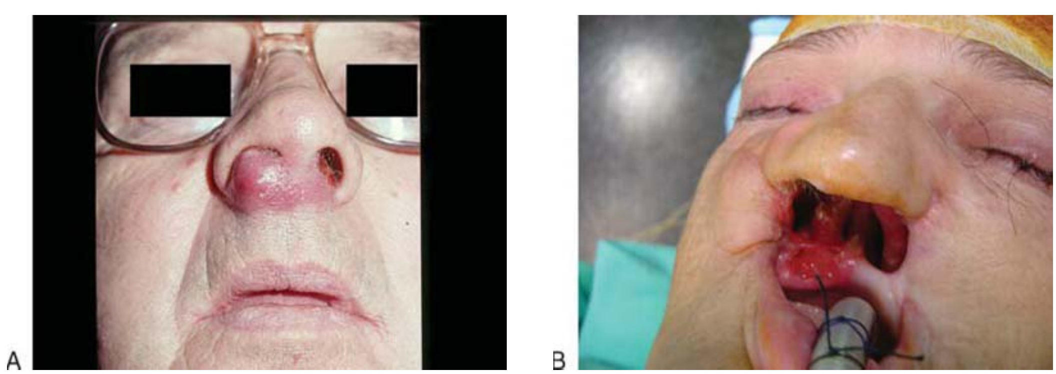

FIGURE 21.2
A: Squamous cell carcinoma of the columella. **B:** Recurrence of cancer following composite resection of the columella, upper lip, premaxilla, and floor of the nose.

CONTRAINDICATIONS

There are few contraindications to surgery based on the local factors, all related to the invasion of critical intracranial structures. Although uncommon, these situations are associated with huge invasive/destructive lesions of the midface and share the same contraindications as the resection of skull base tumors. Patients with comorbidities such as severe cardiovascular and/or pulmonary disease, markedly debilitated or demented patients, or those with end-stage renal disease are usually not candidates for surgery.

PREOPERATIVE PLANNING

Imaging Studies

Imaging studies should always be performed as they provide valuable information that can help in the evaluation of tumor extension, particularly the involvement of paranasal sinuses and orbital cavities. Both computed tomography (CT) and magnetic resonance imaging (MRI) are used in the evaluation of large cancers and the surrounding bone structures. Evaluation of periosteal/bone invasion, as well as invasion of nasal and paranasal sinus cavities, is of utmost importance for surgical planning (Fig. 21.3A–D).

Pathology

Due to the bewildering array of malignancies arising on the skin of the face, accurate pathologic diagnosis is critical. If the patient has not been biopsied previously, obviously biopsies must be done. If patients have been biopsied elsewhere, the slides should be reviewed to make certain of the correct diagnosis.

SURGICAL TECHNIQUE

Under general endotracheal anesthesia, the oropharynx is packed with a damp gauze bolster to prevent aspiration. The patient is prepped and draped, with the face, forehead, and neck exposed for those patients who will receive a neck dissection. Ointment is placed in both eyes, and the eyelids are taped or sutured shut. The proposed area of surgical excision is marked with the surgical pen to delineate adequate surgical margins (Fig. 21.4A).

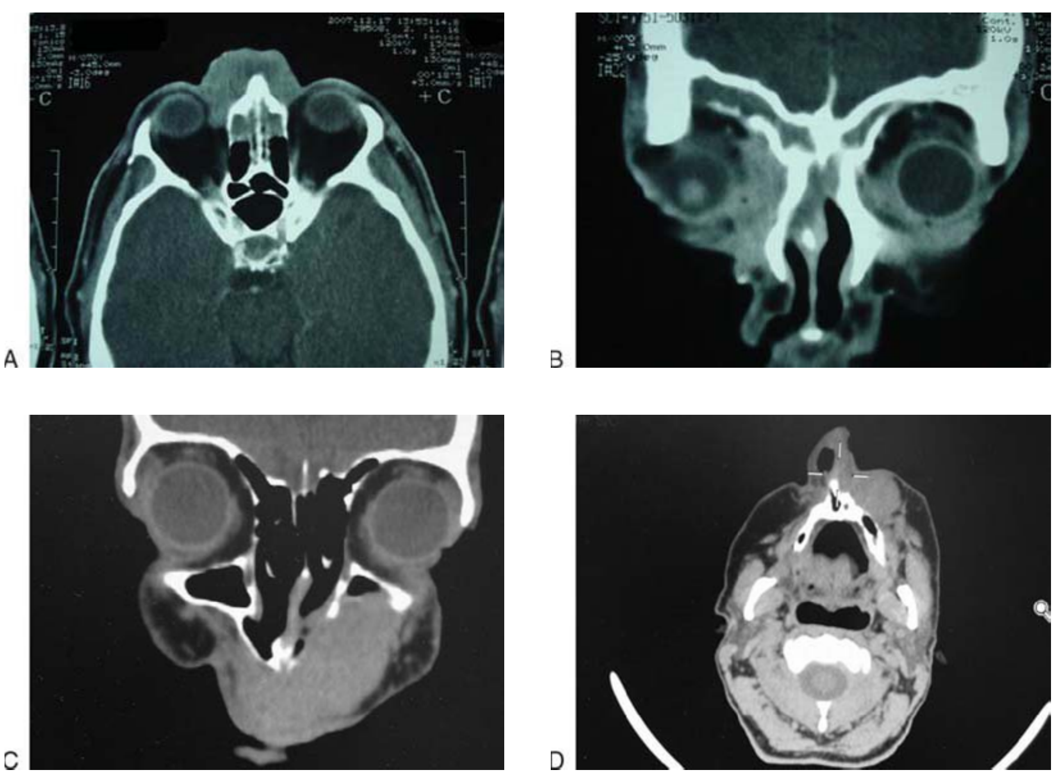

FIGURE 21.3
Aggressive squamous cell carcinoma of the nose infiltrating the orbit, roof of the nasal cavity, and anterior ethmoidal complex. **A:** CT axial view—squamous cell carcinoma of the nose with extensive involvement of the nasal and facial bones and upper lip. **B:** CT coronal view demonstrating orbital invasion. **C:** CT coronal view demonstrating invasion of the left maxillary sinus. **D:** CT axial view demonstrating invasion of the premaxilla.

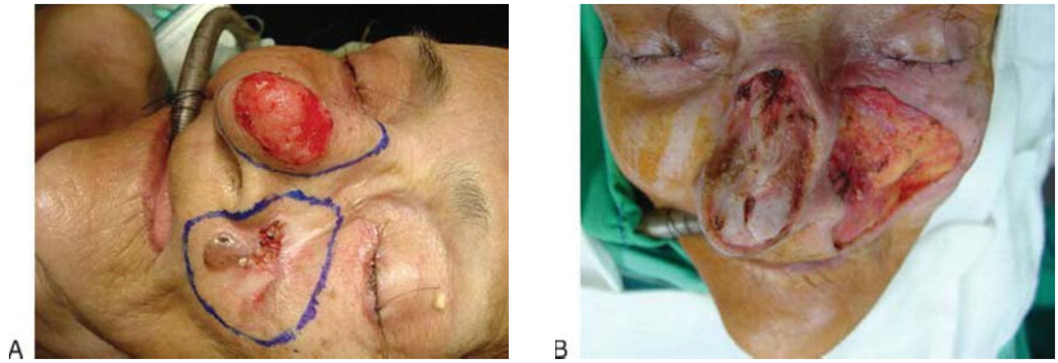

FIGURE 21.4
A: Basal cell carcinoma of the dorsum of the nose and left nasolabial region. The proposed area of surgical resection is marked with a surgical pen. **B:** Resection of the skin of the nose and nasolabial region. Nasal bones and cartilages were not invaded.

Generally the operation is performed through a lateral rhinotomy incision, either unilaterally or bilaterally depending upon the extent of the tumor. The skin incision as previously marked is deepened through the soft tissues up to the underlying bone with an electrocautery. Nasal cartilages are attached to the bone margins and are easily freed by an incision beginning at the lateral edge of one naris and following the edge of the pyramidal opening, which is easily felt (Fig. 21.4B).

After both lateral walls have been sectioned, excision of the columella and anterior septum is carried out under direct vision using a heavy straight septal scissor. A high-speed power saw is used to divide the nasal process of the maxilla on the right side first. A similar osteotomy is made on the nasal process of the maxilla on the left side. A larger portion of the nasal process of the maxilla and medial aspect of the orbit can be removed to obtain adequate bone margins. The inferior half of the nasal bones are divided bilaterally with a power saw to connect the osteotomies on the medial aspect of the orbits bilaterally. Inspection of the remaining nasal cavity allows further removal of bony septum, nasal bones, and the lateral wall of the nose if there is doubt regarding adequate tumor margins (Fig. 21.5).

Cancer extending inferiorly to the lips, premaxilla, or palate requires in-continuity resection. If necessary, small osteotomies can be used to gain entrance to the ethmoid air cells posteriorly up to the nasopharynx. The surgical specimen including the skin of the nose, nasal bones, anterior (or anteroposterior) septum, and columella, with or without a bilateral ethmoidectomy, should be delivered in a monobloc fashion. Two-centimeter soft tissue margins, using frozen section control, must be obtained in all cases. Undercutting of the bony edge of the pyramidal opening and suture of the nasal mucosa and facial skin assist in promoting rapid epithelization of the margins, an essential step before fitting a prosthesis (artificial nose) (Fig. 21.6A and B).

Bleeding of the alar and septal branches of the facial artery and ophthalmic and maxillary vessels is easily controlled. Bleeding from branches of the nasolabial artery and the subdermal plexus of vessels needs to be anticipated as well. In general the bleeding can be controlled with electrocautery, but occasionally ligation of the branches of the nasolabial artery may be necessary. The nasal cavity is packed with a Xeroform gauze bolster. Elective tracheostomy is rarely necessary (Fig. 21.7).

The nasal bones should be preserved, if possible, to provide a stable base for the nasal prosthesis when this is the type of reconstruction planned. On the other side, whenever extensive bone, cartilaginous, dermal, and intranasal involvement is found, additional bone and soft tissue of the face must be included in the resection field in order to guarantee a free-margin oncologic procedure (Figs. 21.8A and B, Fig. 21.9A–D).

FIGURE 21.5
Inspection of the nasal cavity after the resection of the alar rim, lateral nasal wall and columella, and anterior nasal septum.

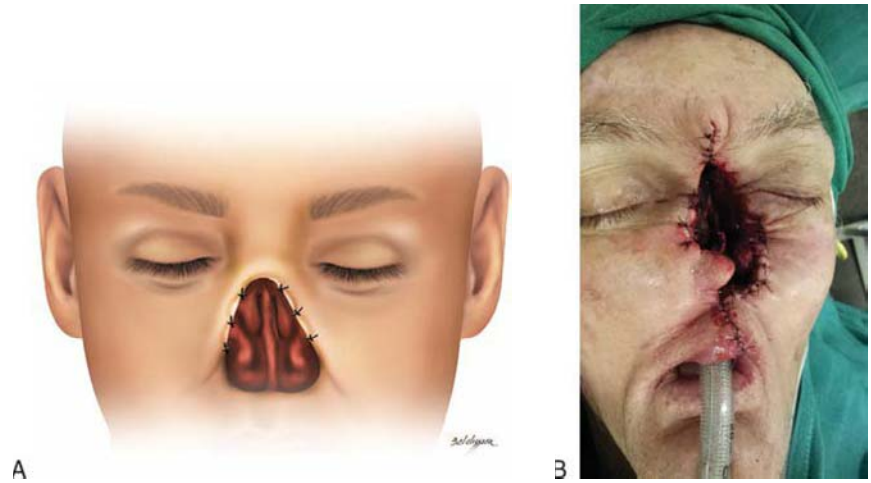

FIGURE 21.6
A: The nasal mucosa was sutured to the facial skin to promote rapid epithelialization of the margins. **B:** Final appearance after total rhinectomy.

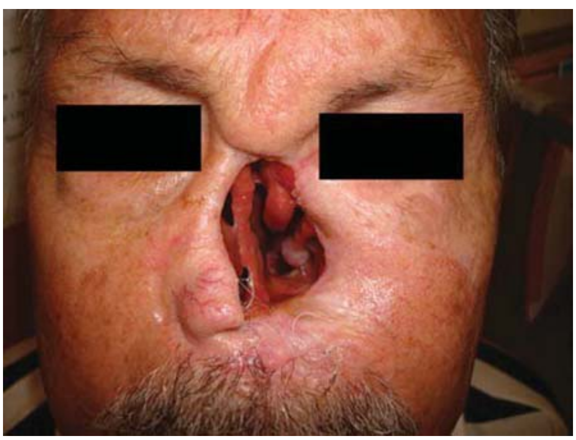

FIGURE 21.7 Delayed nasal reconstruction after subtotal rhinectomy allows better surveillance in patients with high-risk tumors.

FIGURE 21.8 **A:** Squamous cell carcinoma of the nose with extensive involvement of the nasal and facial bones and soft tissue of the face and upper lip. **B:** Extensive defect after total rhinectomy with partial resection of the upper lip and left nasolabial region and partial maxillectomy level II (maxillary bone, premaxilla, and floor of the nose).

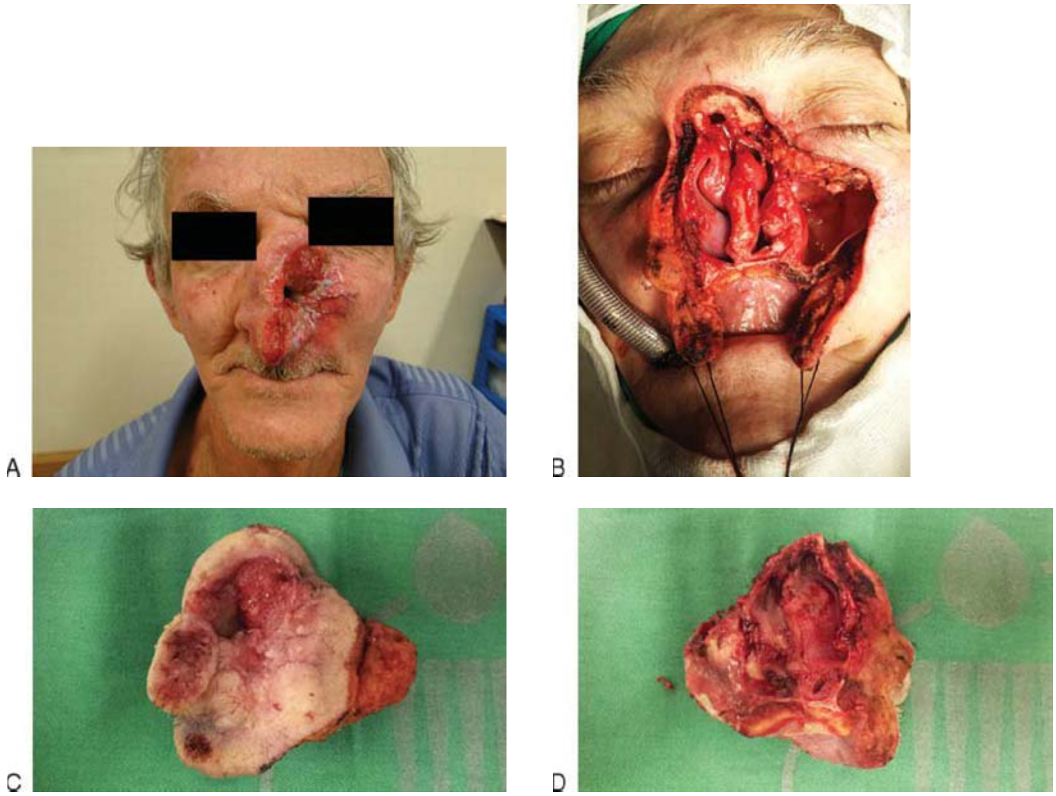

FIGURE 21.9
Squamous cell carcinoma of the nose with extensive involvement of the nasal and facial bones and the upper lip. **A:** Frontal view of the patient. **B:** Extensive defect after total rhinectomy with resection of the upper lip, premaxilla, and anteromedial and lateral aspects of the maxillary sinus. **C:** Surgical specimen, monobloc resection: anterior view. **D:** Posterior view.

For purposes of study, classification of the surgical resection, including rhinectomy and septectomy with maxillary bony resection, is made according to the levels of maxillary bone resection, as follows:

- Level I: premaxilla/nasal floor
- Level II: maxillary face/premaxilla/nasal floor
- Level III: medial maxillectomy
- Level IV: subtotal maxillectomy
- Level V: anterior craniofacial (Fig. 21.10)

Reconstruction of the nasal defect should be delayed until the final pathology report is available, particularly when margins are questionable, and in case of an aggressive histology, deep bone/soft tissue involvement, and perineural invasion.

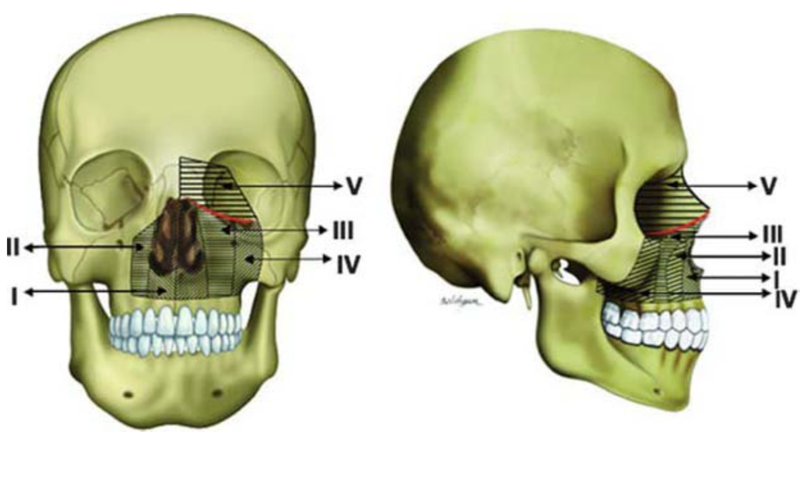

FIGURE 21.10
Classification of maxillary bone resection: level I includes the premaxilla and floor of the nose; level II maxillary bone, premaxilla, and floor of the nose; level III medial maxillectomy; level IV subtotal maxillectomy; level V anterior craniofacial resection. (Adapted from Mignona FV, Garay KF. Surgical rescue of recurrent carcinoma of the nasal columella. *Am J Surg* 1995;170:453.)

POSTOPERATIVE MANAGEMENT

Postoperative management of the patient following rhinectomy with or without maxillectomy centers around the maintenance of optimal hygiene and care of the facial wound until sutures are removed. Meticulous attention is paid to the removal of all clots and crusts over the suture line, as they provide a nidus for infection and may lead to suture line sepsis and occasionally separation of the wound.

Postoperative care also requires intense humidification of the nasal packing to avoid drying and the development of crusting. On the second postoperative day, the patient is taught to irrigate and rinse his oral cavity every 3 to 4 hours with a solution of baking soda and salt in warm water to keep the mouth clean of all debris and secretions. Mechanical cleaning of the oral cavity with a power spray of half-strength hydrogen peroxide and saline is desirable twice daily.

The nasal packing is removed after 5 to 6 days. Debridement of the defect is usually not required; however, vigorous nasal irrigation and provision of excess humidity are vital to remove clots and crusts until complete epithelialization of the defect is achieved.

COMPLICATIONS

Bleeding from the alar and septal branches of the facial artery and ophthalmic and maxillary vessels and from branches of the nasolabial artery and the subdermal plexus of vessels may occur. Other important potential complications include wound sepsis with dehiscence and bone exposure. Complications can be minimized by meticulous hemostasis during the surgical procedure and optimal hygiene of the facial wound.

RESULTS

As with other cutaneous malignancies in general, control rates as well as survival rates associated with cancer of the nasal skin vary with multiple factors. Only a few reports in the literature, in addition to our institutional results, include patients who underwent total or subtotal rhinectomy. As in most series involving nasal skin cancer, there is a high percentage of patients (27% to 51%) who had been treated previously. Recurrence rates are particularly high (32% to 43%), if we consider only series dealing with total or subtotal rhinectomies. Disease mortality rates ranged from 10% to 21% (Table 21.1).

We reviewed our own series of 51 patients with extensive cancer of the nose who underwent rhinectomy between 1989 and 2008. Total rhinectomy was performed in 13 (25.5%) patients, partial in 18 (35.3%), and rhinectomy with additional facial structures in 20 (39.2%). Only 19 (37.3%) patients received adjuvant radiotherapy, and immediate reconstruction was performed in 30 (95.8%). Squamous carcinoma was found in 47.1% of patients, basal cell carcinoma in 25.5%, melanoma in 13.7%, and other histologic types in 13.7%. Free margins were achieved in 38 (74.5%) of patients. Predictive factors for recurrence were positive margins

TABLE 21.1 Malignant Tumors of the Skin of the Nose

Study	Number of Cases	Histology BCC	Histology SCC	Tumors Previously Treated	Recurrence Rate	Lymph Node Metastasis	Disease-related Mortality
Conley (1974)	456	87%	11%	51%	9%	SCC: 18% BCC: 0.25%	2%
Vieira (1981)	124	NA	NA	29%	NA	6%	NA
Goepfert et al. (1982)	305	69%	18%	38%	Prior Tx: 80% No prior Tx: 26%	SCC: 6%	SCC: 7%
Stanley and Olsen (1988)	51	33.3%	49%	61%	43%	4%	21.5%
Teichgraeber and Goepfert (1990)	147	60%	34%	37%	32%	9%	10%
BNCI	51	26%	47%	NA	41.2%	6%	NA

BCC, basal cell carcinoma; NA, data not available; SCC, squamous cell carcinoma; Tx, treatment; BNCI, Brazilian National Cancer Institute.

($P = 0.003$), bone invasion ($P = 0.005$), and diagnosis of melanoma ($P = 0.001$). The 3-year overall survival and disease free survival were 72.5% and 58.8%, respectively.

Postoperative irradiation plays a significant role in the management of advanced cutaneous malignancies. Indications for adjunctive radiation include positive margins, histologic evidence of vascular or neural invasion, and aggressive local behavior (e.g., bone invasion, multiple recurrences, lymphatic involvement).

PEARLS

- Two-centimeter soft tissue margins, with frozen section control, must be obtained in all cases.
- Whenever extensive bone, cartilage, dermal, and intranasal involvement is found, additional (generous) bone and soft tissue of the face must be included to guarantee a cancer free-margin procedure.
- Whenever oncologically possible, the nasal dorsum should be preserved, as it provides a stable base for the prosthesis.

PITFALLS

- Patients should be counseled regarding the likely surgical deformity, and it is essential to involve an experienced maxillofacial prosthodontist preoperatively so that an initial silicone prosthesis can be provided immediately after surgery.
- Patients with invasive/advanced squamous carcinoma involving the columella and/or the nasal vestibule should be carefully evaluated for lymph node metastases. Regional lymph nodes at risk may be considered for elective treatment.
- Since most recurrences occur within 2 years after definitive treatment, avoid immediate nasal reconstruction, particularly when margins are questionable—in case of an aggressive histology, deep bone/soft tissue involvement, and perineural invasion.

INSTRUMENTS TO HAVE AVAILABLE

- Head and neck soft tissue set
- Osteotomes of various diameter
- Nasal septoplasty set, containing Freer and Cottle elevators, nasal specula, and curved scissors
- Allograft material for temporary wound coverage
- Absorbable and nonabsorbable impregnated packing material
- Headlight
- Power saw

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22 TRANSORAL ENDOSCOPIC LASER TREATMENT OF EARLY GLOTTIC CANCER

Steven M. Zeitels

INTRODUCTION

Transoral endoscopic removal of glottic cancer was reported first in 1888 as a mirror-guided piecemeal resection approach. Approximately 30 years later, Lynch reported a bimanual, direct, suspension laryngoscopic method, which was later enhanced by the magnification provided by the surgical microscope. In the early 1970s, Jako, Strong, and Vaughan introduced a carbon dioxide laser that was coupled to the surgical microscope, which ultimately became the watershed innovation that facilitated widespread adoption of endolaryngeal cancer surgery. In recent years, fiber-based delivery systems have further enhanced this method by providing substantially better control of the operative field.

Given the long successful history of endoscopic treatment of early glottic cancer, there is no controversy about its feasibility and success. Unlike other sites of the upper aerodigestive tract, early glottic cancers (T1/T2) rarely metastasize, which provides unique opportunities for staged treatment strategies. Furthermore, since the cure rate is extremely high for any surgical approach or radiotherapy, the key metric for success in our communication-based society is predicated on the voice outcome. It is also important to preserve future treatment options.

Optimal voice preservation is improved by the surgeons' keen awareness of vocal physiology. This understanding of the functional aspects provides insights into the impact on the voice of a spectrum of neoplastic lesions prior to treatment, subsequent to resection, and after phonosurgical reconstruction. The reconstructive strategies are designed to enhance aerodynamic glottal competency. For most patients treated for early glottic cancer, the primary sound source is the uninvolved phonatory mucosa of the vocal fold. Results are improved if this mucosa is spared exposure to radiation treatment or other intervention, which generates fibrosis and scar.

Noncancer phonatory mucosa is driven into oscillation by preserving or reestablishing aerodynamic competency after the tumor is treated. This is achieved by (1) minimizing soft tissue removal through extremely narrow margins; (2) preserving the architecture of the rima glottidis by means of metachronous treatment of each vocal fold, thereby preserving the structure of the anterior commissure; and (3) reconstructing the paraglottic compartment by means of transoral and/or transcervical medialization procedures if an extensive amount of vocal musculature has been removed.

Approximately 7 years ago, I abandoned CO_2 laser excision of early glottic cancer in favor of angiolytic laser involution of the disease so that we could maximize preservation of glottal soft tissue. This has been done primarily with the use of the 532-nm GreenLight KTP laser. More than 75 patients have been treated by this technique with control rates of approximately 95% for T1 cancers and 75% for T2 cancers. Furthermore, the majority of patients with T2 cancers are salvaged with radiotherapy, thereby saving this valuable single-use treatment option in most patients. Moreover, KTP laser treatment resulted in our best voice results to date while not compromising cure of the cancer when using ultra-narrow margins.

HISTORY (Video 22.1)

The primary and key symptom for patients presenting with early glottic cancer is that of vocal dysfunction and hoarseness. Apart from a harsh coarse vocal timber, patients may describe difficulties with pitch variation, pitch breaks, and vocal fatigue and difficulties with projection in settings where there is substantial ambient noise. Most commonly, friends, colleagues, and especially new contacts inquire if he/she is "sick." Airway difficulties, hemoptysis, otalgia, and dysphagia are rare symptoms with early glottic cancer.

PHYSICAL EXAMINATION

Distal-chip flexible laryngoscopy should be done with extremely close proximity to the tumor to define the perimeter of the lesion. To the extent that it is possible in the outpatient setting, the tumor edge should be defined laterally in the ventricle, caudally with relation to the inferior arcuate line and the superior area of the subglottis, anteriorly at the anterior commissure, and posteriorly around the arytenoid cartilage. These findings should be recorded by photos or video. This examination can be enhanced by narrowband imaging, which often highlights angiogenic dysplasia at the perimeter of the lesion.

Stroboscopic examination of the phonatory mucosa can be done with a rigid telescope (Video 22.2; Fig. 22.1A and B) or a flexible laryngoscope. Stroboscopy is valuable in selected circumstances for determining the depth of a neoplasm if a patient has not had extensive biopsies, undergone prior treatment of dysplasia, or had sustained long-term phonotrauma. More importantly, stroboscopic assessment of the glottis provides an assessment of residual pliable superficial lamina propria (SLP), which will be the oscillatory sound source for the patient once the tumor has been successfully treated and aerodynamic competency of the glottal valve reestablished.

Vocal cord mobility must be determined in order to adequately stage the patient's cancer. Diminished mobility may occur from mass involvement of the intrinsic muscles of the paraglottic space or by direct involvement of the cricoarytenoid joint. A T2 cancer may be designated as such due to either surface involvement of either the supraglottis or subglottis or if there is impaired mobility of the glottis. In my opinion, there is greater success in treating T2 cancers with surface involvement of two mucosal subsites compared to impaired mobility due to deep tumor invasion.

INDICATIONS

The indications for endoscopic resection of early glottic cancer include T1a and T1b cancers as well as selected T2a and T2b cancers. It is possible to treat these cancers after failed radiotherapy, but the oncologic and functional results are not as good as with primary treatment. The decision to proceed in cases of radiation failure should be individualized based on the original size and location of the cancer, endoscopic exposure, imaging studies, expectations and motivation of the patient, equipment available, and skill sets of the surgeon.

CONTRAINDICATIONS

The most common contraindication to effectively removing a glottic cancer endoscopically is the inability to fully visualize the neoplasm during suspension laryngoscopy. This primarily occurs due to restrictions in visualization of the anterior glottis due to the anatomy of the patients' oral cavity, mandible, and neck. Some examples of these

A  B 

FIGURE 22.1 **A:** T2b carcinoma of the left vocal fold seen during abduction. The lesion crosses the anterior commissure to the contralateral right vocal fold. It extends past the inferior arcuate line caudally to the upper subglottis. The superior–lateral extent of the disease on the ventricular surface of the vocal fold cannot be determined on this examination. There is normal vocal fold mobility. **B:** On adduction and stroboscopy, there is no mucosal wave seen in the left vocal fold, and it is impaired on the right.

problems include limited mouth opening, a narrow mandibular arch or torus deformities, and/or limited or narrow oropharyngeal inlet with relative macroglossia. It may also occur due to limitations of extension at the atlanto-occipital joint or severe fibrosis of the soft tissues of the neck secondary to radiation or burns. Less commonly, a neoplasm has an unfavorable pattern of invasion so that despite reasonable laryngoscopic exposure, it cannot be reliably eradicated. Typically, these problems are determined during the preoperative evaluation.

Severe cardiopulmonary disease precluding general anesthesia is rare but certainly occurs. Anticoagulation is a relative contraindication based upon the size of the tumor, the difficulty in exposure, and the laser technology that is available. Fiber-based lasers are easier to use in patients who are anticoagulated. This is especially true for the KTP laser and the thulium laser. Understandably, cancer that invades cartilage or escapes through the connective tissue of the laryngeal framework is not generally considered to be suitable for an endoscopic procedure.

PREOPERATIVE PLANNING

After careful office evaluation, the digital video should be reviewed with the patient so that he/she is fully prepared for the management. This will assist greatly with the patient's expectations. Since, in my practice, patients with bilateral cancer are treated with metachronous procedures approximately 6 weeks apart (to preserve the architecture of the anterior commissure), the patient will need to be prepared for this prospect. They should also understand that if the tumor substantially invades the vocal musculature, they may need a reconstructive medialization by means of transoral lipoinjection or transcervical medialization.

Patients should understand the fact that radiation is typically considered a single-use treatment option, which is valuable and should be preserved if possible for future use in the event that more extensive lesions arise. This is important since individuals who develop glottic cancer are prone to have metachronous cancers in this region. They should also understand that radiotherapy must be administered to both vocal folds and to the noncancer phonatory glottal tissue, which may impair its function as well. This is especially true in patients who have been noted on stroboscopy to have generalized loss of pliable phonatory mucosa from phonotrauma or prior glottal procedures such as treatment for prior dysplasia. Smaller lesions do not require radiographic imaging; however, it should be considered with larger T2 lesions.

In our view, acoustic and aerodynamic testing, although not mandatory, is of value similar to obtaining an audiologic evaluation prior to an otologic procedure. Patients will also need to understand that one of the great values of endoscopic removal is that in the event of a recurrence or second primary, all treatment options are preserved, including endoscopic re-resection, transcervical resection, and radiotherapy. Finally, patients should be aware that it is not uncommon for individuals who have had treatment for early glottic cancer to develop posttreatment recurrent keratosis with dysplasia without developing invasive carcinoma and that this can typically be managed with office-based intervention.

TECHNIQUE

Ideally, the surgeon who is doing the resection should intubate the patient so that the tumor is not disturbed or disrupted prior to the tumor removal. Anesthesia should be induced with paralysis prior to placing an endotracheal tube to also ensure that the tumor is not traumatized prior to the microlaryngoscopic examination. If there is extension of the disease posterior to the arytenoid region, it is wise to use a jet ventilation catheter such as the Hunsaker device (Xomed Corporation). Understandably, the anesthesiologist must be very comfortable with this approach.

Laryngoscopic exposure is obtained by placing the patient in the Jackson position with the neck flexed in relation to the chest and the head extended at the atlanto-occipital joint. The surgeon should select the widest bore speculum that can be placed through the oral cavity to the glottis. I use the universal modular glottiscope since its lancet-arch shape is designed to conform to the inner contour of the thyroid lamina. This allows for full exposure of the anterior commissure tendon and posterolateral paraglottic space, both of which can be challenging to achieve with an ovoid-shaped direct laryngoscope. Furthermore, a true suspension gallows is employed, which applies the force on the mandible rather than applying a fulcrum force on the maxilla, which is done with laryngoscope holders and chest wall stabilizers. The precision of the procedure will often be based on the adequacy of the exposure, and a suspension gallows has long been demonstrated to allow for placement of a larger caliber direct laryngoscope.

It is not uncommon for a tear to occur in the floor of mouth and glossotonsillar region when positioning a large-bore laryngoscope and using suspension. This is considered to be a normal outcome for obtaining optimal exposure, when there are restrictions in positioning a large speculum. This type of unavoidable blunt trauma may also lead to temporary numbness of the tongue and changes in taste. I typically administer IV dexamethasone prior to the procedure primarily with the hope of minimizing the symptoms of oral cavity soft tissue trauma; however, I have no proof of the efficacy of treatment.

Once the cancer is exposed, a biopsy is obtained for frozen section. An analysis by a well-qualified head and neck pathologist is done if a cancer diagnosis has not already been obtained prior to the procedure. The procedure is frequently begun by removing the vestibular fold if it is obscuring visualization of the tumor in

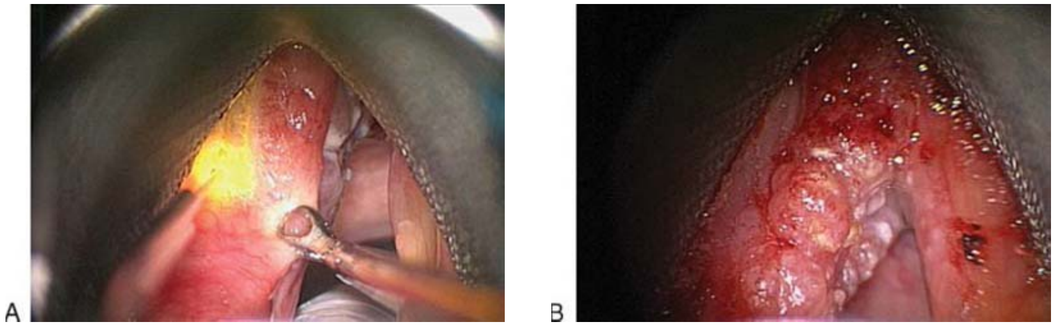

FIGURE 22.2
A: The left vestibular fold is resected with the laser at 15 W with cooling to visualize the glottic surface in the ventricle. **B:** The glottic cancer is more completely visualized after the vestibular fold is resected.

the ventricle on the superior surface of the vocal fold (Video 22.3; Fig. 22.2 A and B). If the cancer involves the arytenoid, I typically begin from posterior to anterior. Consequently, the jet ventilation catheter can be replaced with a conventional endotracheal tube once the posterior aspect of the cancer is removed. If the cancer does not involve the arytenoid and a conventional endotracheal tube has been placed, I typically begin with removal of the anterior aspect of the lesion first. If the cancer involves the anterior vocal fold(s), exposure of the medial surface of the anterior commissure is obtained by placing a cord spreader posteriorly to widely distract the vocal folds (Video 22.4; Fig. 22.3 A–D).

I have demonstrated that staging the resection of the cancer in two procedures is not detrimental to the oncologic outcome in early glottic cancer, yet it can substantially improve the voice outcome by preserving the architectural anatomy of the anterior commissure. Three-year follow-up on a larger cohort of patients has further supported the original findings (unpublished data; This paper is with the Laryngoscope awaiting decision in the second review. I hope to hear about it within the month). As necessary, the supraglottic soft tissues cephalad to the neoplasm can be removed to adequately expose the superior surface of the glottis to ensure that cancer is not left behind in the lateral aspect of the ventricle.

When managing T1a cancer, approximately half of the lesions will not extend completely through the SLP and attach to the vocal ligament. This can be typically visualized by performing a sublesional infusion of saline and 1:10,000 adrenaline. These types of early cancers are well suited to a cold instrument microflap resection to optimally preserve residual glottic soft tissue. For many years, I used a mirror-guided CO_2 laser for the larger lesions, which extended to the vocal ligament or deeper.

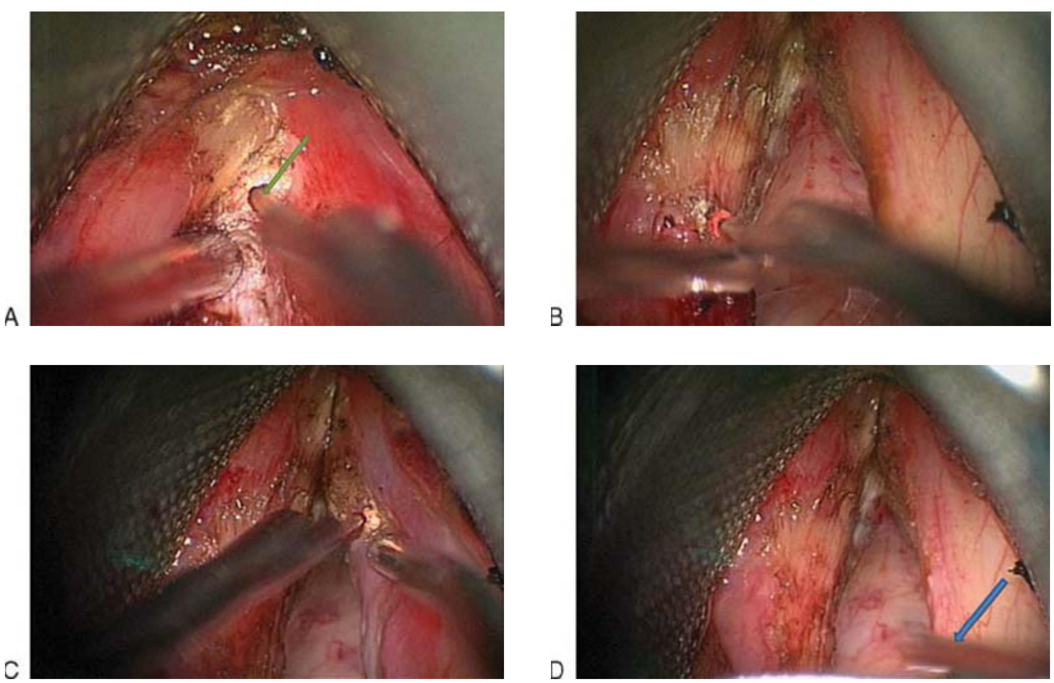

FIGURE 22.3 **A:** The anterior margin of the resection is established in a pulsed mode (*green arrow*). Note that the field is relatively bloodless, which enhances visualization. **B:** The tumor involution is done in the midvocal fold. Note that the linear striations of the underlying normal soft tissue of the vocal fold are easily seen, which allows for maximal preservation of the layered microstructure of the vocal fold. **C:** The right vocal fold is treated in the midregion with a laser fiber. The medial anterior commissure region is not treated to avoid anterior cicatrization. **D:** The first stage of the tumor removal is completed. Note again that there is a limited volume of disease that has been left intentionally on the right vocal fold (*arrow*).

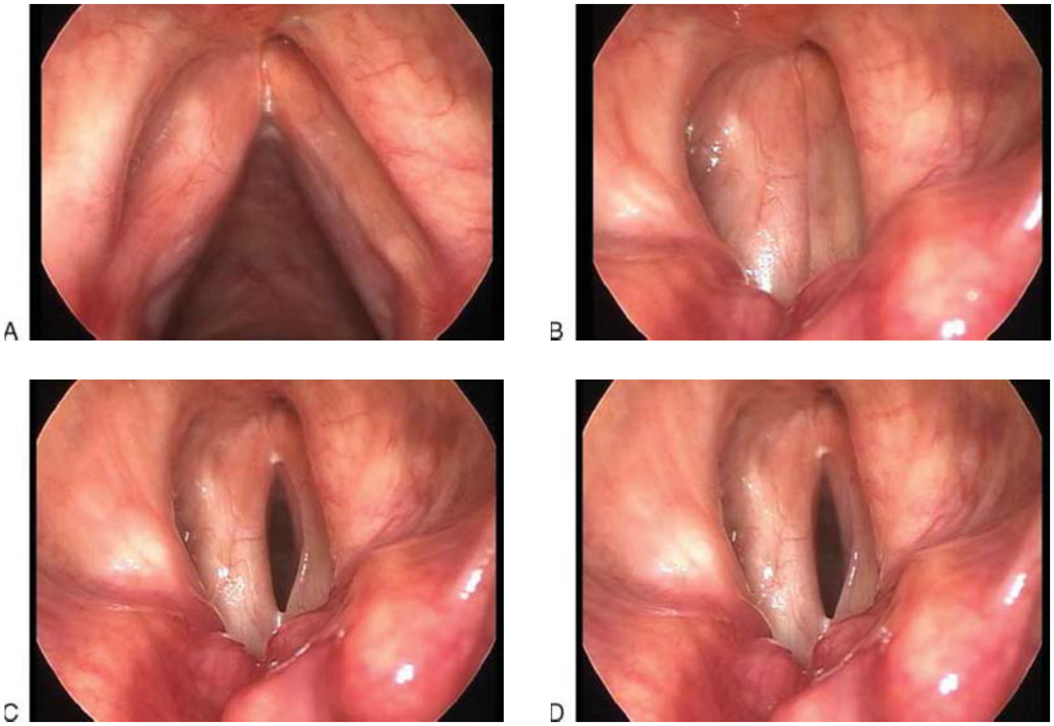

FIGURE 22.4 **A:** The office examination after the second stage during abduction reveals that there is no evidence of cancer and the vocal fold has become mucosalized. Note the soft tissue deficit where the left vestibular fold has been resected and the normal architecture of the anterior commissure. **B:** On adduction, the vocal folds close completely. This patient had a normal conversational-level voice subjectively and based on objective acoustic and aerodynamic measures of vocal function. **C:** During stroboscopy, the pliability of the right vocal fold is maintained and the deformation of the right phonatory mucosa can be easily seen. **D:** During stroboscopy, further excursion of the right mucosal wave can be seen.

I abandoned the CO_2 laser in favor of an angiolytic 532-nm KTP laser approximately 7 years ago. This laser is delivered on a 0.3-, 0.4-, or, 0.6-mm glass fiber through a specially designed, double-lumen, suction-type cannula. Prior to using the laser, wet eye pads are placed on the patients eyes along with wet towels to cover the face. A laser-resistant endotracheal tube should be used with a wet Cottonoid placed subglottically over the cuff of the endotracheal tube. When resecting the supraglottic soft tissue that is not involved with the neoplasm, we usually use the setting of 10 to 15 W. Cold air is insufflated through the parallel double cannula, which is also holding the laser fiber. This diminishes heat in the operative site and thereby minimizing the "oven" effect.

Adequate margins are achieved through careful microlaryngoscopic examination and frozen section soft tissues biopsies at the tumor perimeter from the patient to establish clear margins. This approach has allowed for ultra-narrow margins. However, my voice results have substantially improved, and phonosurgical reconstruction is done substantially less frequently. Once frozen section analysis has established that the cancer has been completely removed, the larynx and trachea are suctioned clear. The patient is taken out of suspension and the larynx is sprayed with topical 4% lidocaine. The patient is extubated in the operating room and is transferred to the recovery room with humidified room air.

POSTOPERATIVE MANAGEMENT

Postoperatively, patients are instructed to keep well hydrated and are placed on reflux precautions. If a superficial cancer resection is done within the SLP, the patients are kept on voice rest for 10 to 14 days to limit phonotrauma to the residual delicate SLP. It will take 8 to 12 weeks to epithelialize the wound based on the defect. Once epithelialization is complete, it is valuable to assess the glottal sound source with stroboscopy to determine if a phonosurgical procedure would enhance aerodynamic competency (Video 22.5 Fig. 22.4A–C).

COMPLICATIONS

Generally complications are uncommon; however, there is a small incidence of hemoptysis during the first 2 weeks, which is about 1%. Older individuals with age-related decreased sensation of the pharynx who undergo partial arytenoid resections may note initial difficulties with deglutition.

RESULTS

This treatment was initiated as a further development of conventional endoscopic carbon dioxide laser resection. There are more than 50 patients who have greater than 3-year follow-up with T1 cancer and more than 20 patients with a similar follow-up with T2 cancer. The overwhelming majority of patients in the T2 group had cancer present in both vocal folds. Oncologic control was approximately 95% in the T1 cancer and approximately 75% in the T2 cancers. Those who recurred received radiotherapy, and the majority were controlled with this modality. Only one patient thus far has required a total laryngectomy. Radiotherapy was used in approximately 10% of patients. Objective acoustic and aerodynamic data reflect that the voice results using this technique are the best we have achieved to date (Video 22.6).

PEARLS

- Successful endoscopic resection of glottic cancer is best achieved with the widest-caliber, optimally shaped laryngoscope speculum that can be placed from the mouth to the glottis.
- The lancet-arch shape of the universal modular glottiscope was designed to accommodate the inner contour of the thyroid lamina and therefore is ideally configured to expose both the anterior commissure tendon and the posterolateral paraglottic musculature. This facilitates an optimal oncologic resection.
- A suspension gallows, which applies force to the floor of the mouth, tongue, and mandible, allows for the widest bore laryngoscope that can be placed.
- The vocal outcome subsequent to glottic cancer resection is inextricably dependent on the location and volume of SLP within the phonatory mucosa of either vocal fold that can be preserved.
- For superficial glottic cancer, cold instrument resection and angiolytic 532-nm pulsed-KTP laser tumor removal can be used with equal effectiveness for oncologic efficacy and voice outcome. However, pulsed-KTP laser treatment is substantially faster and easier to perform.
- Fiber-based laser delivery systems are more effective and easier to use than mirror-guided, line-of-sight delivery systems for most surgeons.
- T2 lesions that receive this staging based on two surface geographic sites of involvement are more successfully treated than T2 lesions with substantial impaired mobility of the vocal fold.
- Glottic cancer that extends over the superior surface of the ventricular mucosa is best exposed by first resecting the vestibular folds and infrapetiole region through the thyroepiglottic ligament.
- Laryngeal stroboscopy is effective for identifying residual pliable phonatory mucosa for prognosticating voice outcome; however, stroboscopy is not reliable for determining the depth of tumor invasion.

PITFALLS

- KTP laser ablation of early glottic cancer is not done by providing a specimen with margins to the pathologist. The surgeon removes the disease based on high-magnification visually controlled assessment of the laser-generated combustion of the tumor and the normal perimeter soft tissue. There is substantially more combustion and carbon where there is neoplastic angiogenic high-density microcirculation.
- Fifty percent of T1a glottic cancers do not invade the vocal ligament. Overresection of these lesions may cause aerodynamic glottal incompetence during phonation.
- Laryngeal stroboscopy may identify residual pliable phonatory mucosa for prognosticating voice outcome but should not be used for determining the depth of tumor invasion.

INSTRUMENTS TO HAVE AVAILABLE

- Universal modular glottiscope
- True suspension gallows
- 532-nm KTP laser that accommodates a 0.3- to 0.6-mm range of fibers
- A double-cannula handpiece to deliver the laser fiber as well as pressurized air to insufflate through the second cannula port
- Full complement of Jako-sized microlaryngeal instruments as well as mini-microlaryngeal instruments
- Laryngeal cord spreader to facilitate anterior commissure dissection
- Laryngeal telescopes to assess the ventricle and subglottis
- Capability to use a Hunsaker jet ventilation catheter as well as laser-protected endotracheal tubes
- A surgical microscope capable of 10× to 13× magnification
- Operating chair with arm rests to limit the instability of hand motion and tremor
- Laryngeal telescopes to view tangential mucosal surfaces
- Laryngeal suction cautery for larger vessels that can be occasionally encountered such as the vascular arcade just inside the thyroid lamina

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23 VERTICAL PARTIAL LARYNGECTOMY

Jonas T. Johnson

INTRODUCTION

Vertical partial laryngectomy (VPL) is a surgical procedure that has been developed to preserve laryngeal function during the treatment of invasive cancer. Hemilaryngectomy refers to a procedure in which a single vocal fold is excised, employing a transcervical approach in which the deep margin is the ipsilateral thyroid cartilage. This procedure is largely obsolete for the primary treatment of small vocal fold lesions because most of these lesions can be removed endoscopically with good oncologic results and preservation of vocal function.

Frontolateral hemilaryngectomy is an appropriate term used to describe an external approach for laryngeal cancer in which the anterior commissure is resected with the overlying thyroid cartilage. Once again, this procedure has largely been replaced by endoscopic approaches but may occasionally be employed for patients in whom the larynx cannot be adequately exposed endoscopically. VPL was designed to treat patients with small cancers (T1 and T2) limited to the true vocal fold. This generally means that they can have no more than 10 mm of subglottic extension. Involvement of one arytenoid can be encompassed through resection and reconstruction of that arytenoid; however, involvement of both arytenoids is a contraindication to this procedure. Similarly, extension to involve the supraglottis is a contraindication to partial vertical laryngectomy.

HISTORY

Cancer of the true vocal fold almost always presents initially with dysphonia. The diagnosis requires clinical suspicion, recognition of an abnormality on clinical examination in the office, and histologic confirmation through biopsy. The overwhelming majority of patients with laryngeal cancer have squamous carcinoma, which is associated with exposure to cigarette smoke. Inasmuch as 5% of patients may present with simultaneous second primary squamous carcinoma, a detailed history and comprehensive physical examination including endoscopic evaluation of all of the mucosal surfaces of the upper aerodigestive tract is recommended. The value of routine bronchoscopy and esophagoscopy is controversial and not routinely employed by me, unless symptoms or radiographic findings suggest additional pathology.

PHYSICAL EXAMINATION

Transnasal flexible laryngoscopy in the office is appropriate for any patient with hoarseness. Assessment of the extent of tumor and vocal fold mobility offers the surgeon an estimate of the depth of invasion and helps to stage the cancer. Videostroboscopy may offer further clues about depth of invasion and the suitability for endoscopic transoral resection.

Physical examination should include careful palpation of the neck to include assessment of a potential delphian node at the cricothyroid membrane. Pathologic adenopathy suggests advanced disease and in the setting of a very limited lesion of the true vocal fold, may indicate a second primary cancer.

INDICATIONS

VPL may be the ideal laryngeal conservation procedure for certain patients who have failed radiation therapy for small (T1 and T2) glottic cancers. VPL is largely obsolete for previously untreated T1 and T2 glottic cancers, inasmuch as these tumors can be removed endoscopically in most circumstances. Frontolateral vertical laryngectomy is a suitable alternative for lesions involving the anterior commissure and yields better oncologic results than primary radiation therapy. This improved local control comes at the expense of moderate dysphonia in all patients. Fewer than 5% of patients require total laryngectomy for recurrence of these early cancers.

CONTRAINDICATIONS

Tumor extension to involve the supraglottic larynx is a contraindication to VPL. Similarly, involvement of more than 10 mm of subglottic mucosa, the laryngeal cartilaginous framework, or involvement of both arytenoids should always be considered a contraindication. Patients with severe comorbidities may be better served with a nonsurgical management scheme.

PREOPERATIVE PLANNING

Patients judged to be suitable candidates for partial vertical laryngectomy may benefit from fine-cut computed tomography (CT) of the larynx to allow the surgeon better assessment of the depth of invasion and subglottic involvement. CT should also confirm the absence of adenopathy. Tumor that extends more than 10 mm below the vocal fold or the presence of paraglottic invasion is a contraindication to this procedure.

In the setting of failed primary radiation therapy, an accurate assessment of the original size and location of the primary tumor facilitates treatment planning. In this regard, there is little substitute for having seen the cancer yourself prior to radiation therapy. Modern imaging will not completely localize multifocal recurrent disease, which, in turn, explains the need for total laryngectomy employed for many patients facing this problem.

When partial vertical laryngectomy is deemed appropriate, the surgeon can enhance the planning process through direct microlaryngoscopy and direct inspection of the larynx and palpation of the vocal cords prior to definitive resection. When the anterior commissure is involved, it allows the surgeon to estimate the need and amount of contralateral true vocal fold, which must be removed. It allows confirmation of whether there is <10 mm of subglottic extension, and it allows the surgeon to reassure himself that at least one arytenoid can be preserved.

When both arytenoids can be preserved, chronic aspiration is rarely a postoperative problem. Accordingly, even patients with moderately severe chronic obstructive pulmonary disease may be candidates. All patients, however, should be counseled that temporary tracheostomy and a nasogastric feeding tube will be required.

At the time of direct laryngoscopy, the surgeon can confirm for himself the potential need for reconstruction of either the anterior commissure or an arytenoid. In general, at least two-thirds of one membranous vocal fold is required to allow primary closure with an adequate airway. When tumor requires resection of more than one-third of both vocal folds, I recommend reconstruction of the lumen of the airway with an epiglottopexy to prevent stenosis of the larynx.

Resection of the vocal process of the arytenoid can be routinely undertaken without special intervention; however, when the entire arytenoid must be removed because of cancer, it must be reconstructed to reduce aspiration.

SURGICAL TECHNIQUE

The procedure is performed under general endotracheal anesthesia. The patient is positioned in the supine position with the neck extended on a shoulder roll. After completion of the prepping and draping activities, a short transverse incision is made in a suprasternal skin crease to allow a tracheostomy to be accomplished between the third and the fourth tracheal ring. An endotracheal tube is placed in the tracheostoma. Removal of the endotracheal tube allows for better visualization of the vocal cords. A more superiorly placed tracheostomy is to be avoided as it may compromise the partial laryngectomy.

A transverse incision is then made in a skin crease at approximately the level of the thyroid notch. This is carried down to the strap muscles, and the skin is elevated to the hyoid bone superiorly and to the cricoid cartilage inferiorly. The strap muscles are then separated in the midline and elevated to expose the thyroid cartilage.

The external perichondrium of the thyroid cartilage is incised in the midline. A Freer elevator is used to elevate the perichondrium laterally such that it opens like a book. This requires that the periosteum be incised along both the inferior as well as the superior border of the cartilage (Fig. 23.1). The elevation should continue laterally on the side of the tumor until it is connected to the most lateral 5 mm of the thyroid cartilage. The elevation on the uninvolved side generally can be stopped after approximately 8 to 10 mm.

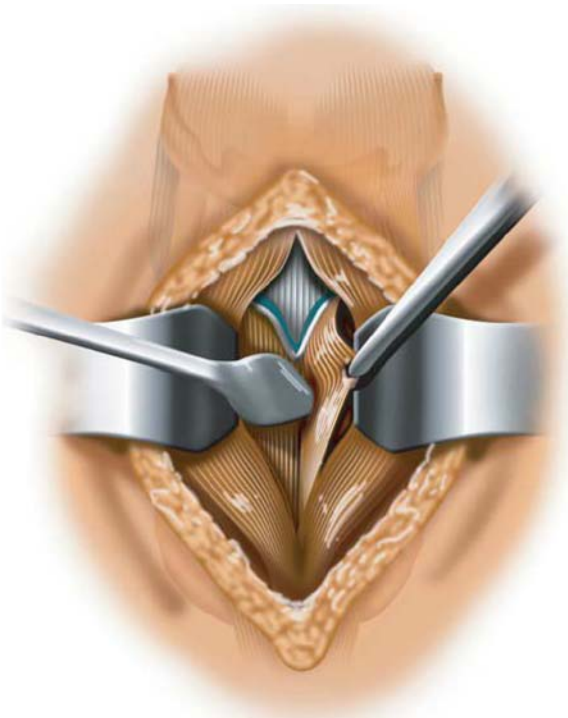

FIGURE 23.1 A Freer allows the elevation of the external perichondrium via cricothyrotomy.

Vertical incisions are then made through the thyroid cartilage using an oscillating saw (Fig. 23.2A). The incision on the side of involvement should be made about 6 to 8 mm from the posterior border of the thyroid cartilage (Fig. 23.2B). The orientation of the saw must be made such that it is perpendicular to the plane of the cartilage. The surgeon must avoid incising the soft tissue beneath the cartilage. In young people, this incision can sometimes be made with scissors; however, the tendency of cartilage to calcify requires a saw in most cases. The cartilage incision on the uninvolved side or in the case of an anterior commissure lesion on the side

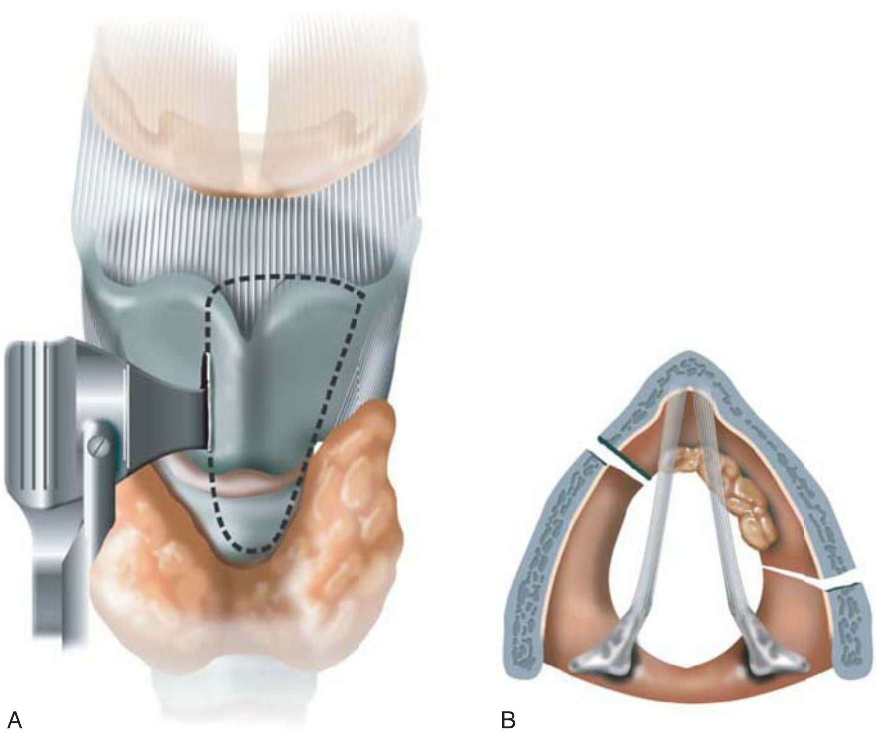

FIGURE 23.2 **A,B:** The cartilage cuts are designed to remove the entire tumor while preserving supporting cartilage.

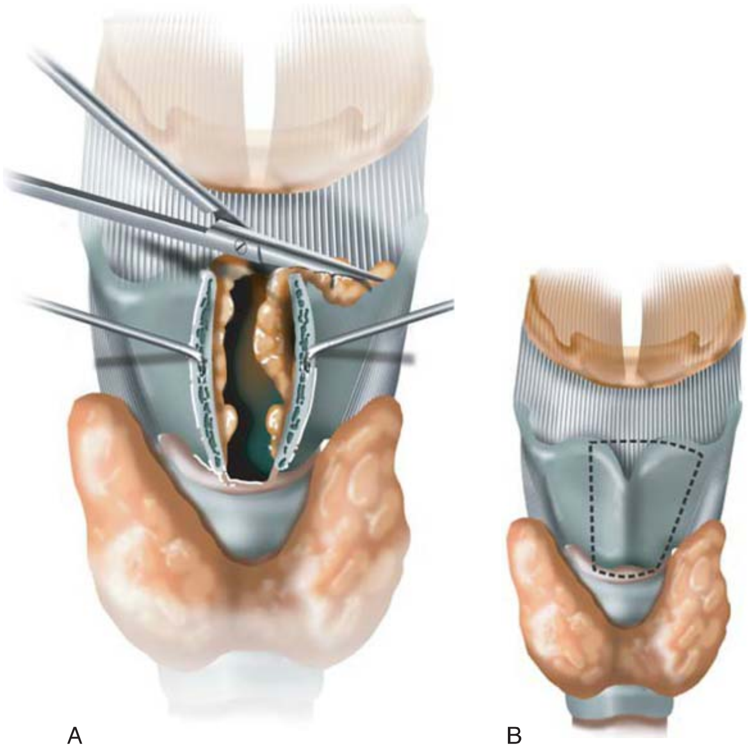

FIGURE 23.3
A,B: Cricothyrotomy allows the soft tissue cuts so the larynx can be opened.

of lesser involvement should be adjusted depending on the size and location of the cancer to maximize the amount of cartilage preserved without compromising the resection margin. This estimation is usually enhanced if the lesion has been observed directly.

Cricothyroidotomy is now accomplished (Fig. 23.3). The height of the cricothyroid membrane is generally 8 to 10 mm. The incision is placed in the middle of the membrane unless there is an oncologic reason requiring it to be positioned more inferiorly. A wide cricothyrotomy improves visibility.

The surgeon, using a headlight, should look through the cricothyrotomy and examine the true vocal folds from below. It is important that the patient be paralyzed. An assistant can retract the previously incised cartilage to enhance visibility. The surgeon, employing a 15 blade, then introduces the (Fig. 23.4) blade into the airway and lifts up in a single stroke to separate the tumor from normal mucosa, hoping to achieve a 1- or 2-mm margin. The plane of the incision must be perpendicular to the plane of the mucosa. Estimating where to place this incision is especially difficult in patients who have failed prior radiation therapy; frozen section analysis of the residual vocal fold is prudent in most cases. Following incision of the vocal fold, the thyrotomy is opened widely and the rest of the resection carried out using electrocautery. The exception to this should be when separating the posterior margin of the tumor from normal mucosa. Once again, hoping to achieve a 1- to 2-mm margin, a portion of the residual vocal fold should be submitted for frozen section.

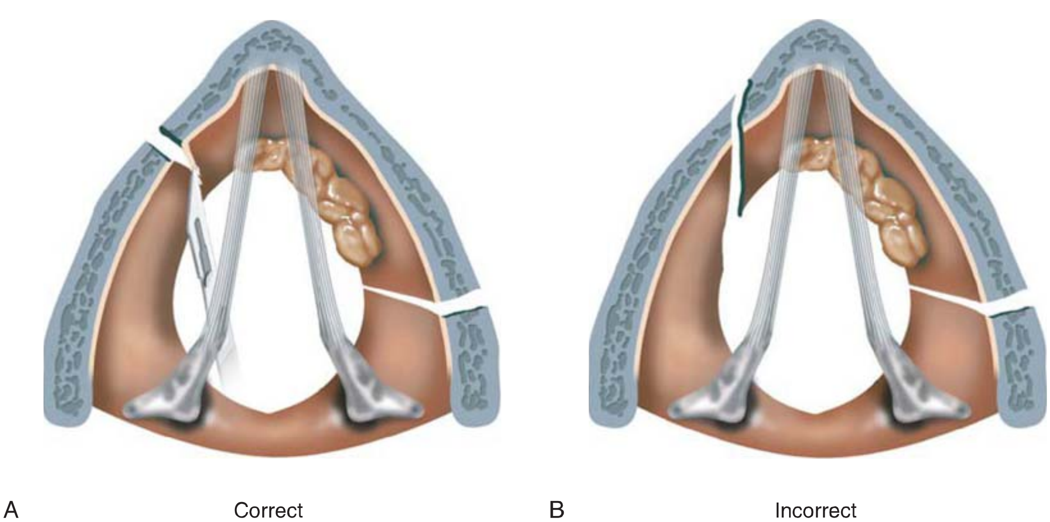

FIGURE 23.4
A: Illustration demonstrating view through cricothyrotomy.
B: Incorrect diagonal cut wastes valuable mucosa.

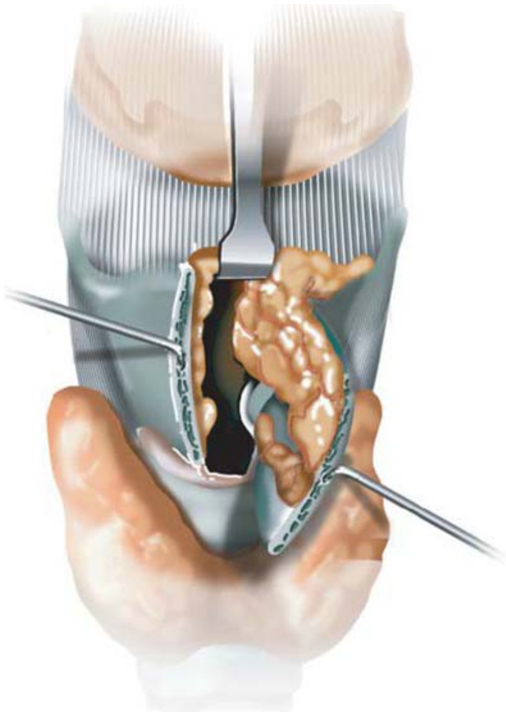

FIGURE 23.5 The posterior incision is adjusted to assure tumor removal.

Surgical resection of previously untreated squamous cancer involving the true vocal folds requires only a very narrow margin. I always send a margin separately for frozen section evaluation because of the potential for confusion in the pathology laboratory. Both vocal fold margins should be evaluated. The superior and inferior margins are generally adequately evaluated directly and can wait for permanent section evaluation.

If the posterior margin comes across the vocal process or the face of the arytenoid, the resected vocal fold need not be reconstructed if there is mucosa on the contralateral vocal fold to ensure an adequate airway (Fig. 23.5). It is essential to tack the anterior, less involved, vocal fold to the thyroid cartilage to prevent retraction (Fig. 23.6). If a significant amount of the contralateral vocal fold has been removed, then reconstruction is necessary to improve the luminal diameter of the airway and to prevent stenosis. This is accomplished with an epiglottopexy.

When both arytenoids are preserved, swallowing is rarely an issue and aspiration is relatively unusual. Laryngeal stenosis reflects inadequate residual mucosa and cartilage supports. Accordingly, the decision to reconstruct with the epiglottis is important. In general, if over half of the less involved vocal fold is removed, reconstruction is necessary.

Epiglottopexy is accomplished by gently grasping the inferior cut edge of the epiglottis (Fig. 23.7A–C). The epiglottis is placed under some tension and the suspensory ligaments, which are located on the anterior

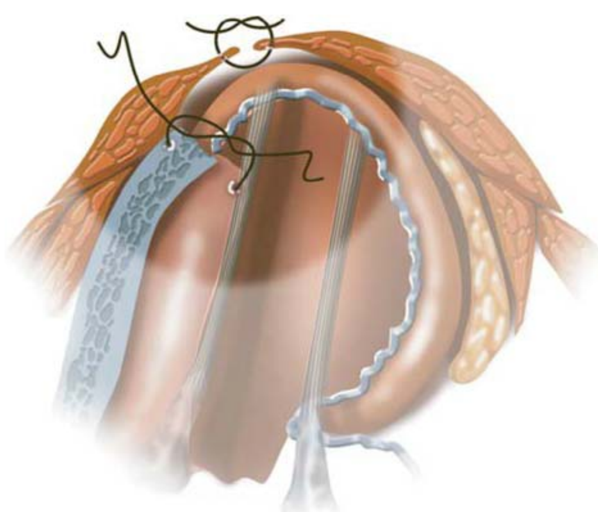

FIGURE 23.6 The less involved vocal fold is sutured to the residual cartilage to preserve its length.

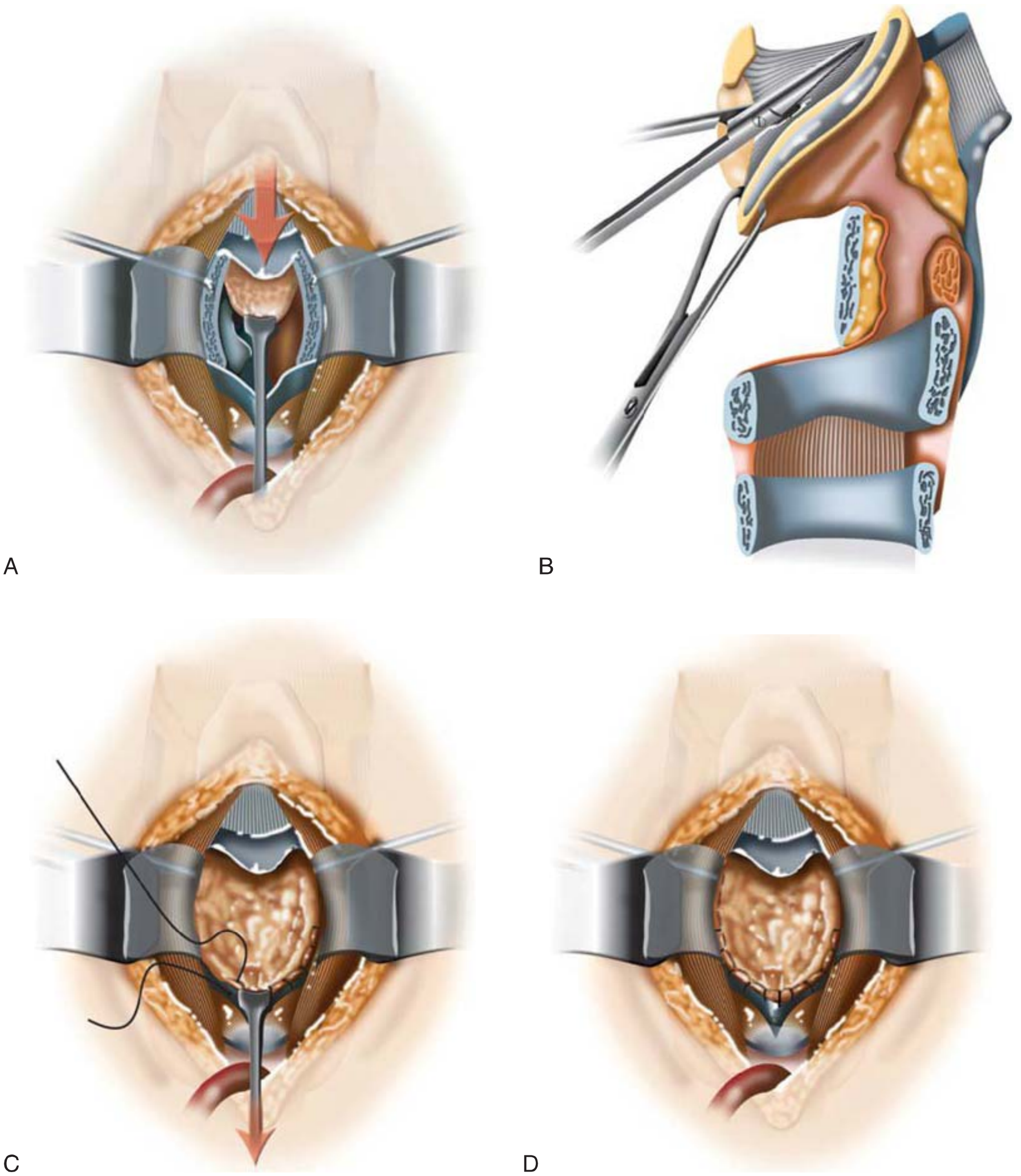

FIGURE 23.7
A: The epiglottis is freed by releasing the soft tissue attachment anterior to it. **B:** The sagittal illustration demonstrates the release maneuver. **C:** The reconstruction is completed by suturing the epiglottis to the cricoid. **D:** Finished closure.

aspect of the epiglottis, are released. This allows the epiglottis to be drawn down such that it can be approximated to the superior surface of the cricoid cartilage without undue tension. The use of the epiglottis provides instant replacement of the resected cartilage and mucosa with like elements, providing epithelial lining and cartilage support to prevent laryngeal stenosis.

Reconstruction of the resected arytenoid can most easily be accomplished with an advancement rotation mucosal flap from the adjacent pyriform sinus. This is rotated superiorly and sutured with small absorbable sutures to the cut edge of the residual mucosa. If the body of the arytenoid requires resection, this, too, must be reconstructed to prevent or reduce aspiration. This is accomplished by suturing the anterior end of the residual true vocal fold, which is then fixed to the anterior aspect of the residual thyroid cartilage, using a 4-0 nonabsorbable suture. If calcification of the cartilage risks fracturing the residual cartilage, a small drilled hole will work nicely. The suture is placed so that the knot is located on the lateral aspect of the thyroid cartilage. The cut edge of the mobilized epiglottis is sutured to the superior surface of the cricoid cartilage approximating the edge of the cricoid to the edge of the epiglottis (Fig. 23.7D) with the nonabsorbable sutures placed such that the knots are not exposed on the surface of the mucosa.

The closure proceeds by approximating the perichondrial flaps in the midline. This closure is almost never water tight. I use a small Penrose drain, which can be brought out through the incision instead of suction drains. The strap muscles are reapproximated in the midline and the skin closed in layers. A cuffed tracheostomy tube is inserted as the endotracheal tube is withdrawn.

Perioperative antibiotics effective against oral flora and administered in sufficient quantity to exceed the minimal inhibitory concentration of common bacteria should be initiated at the induction of anesthesia. Clindamycin, 600 mg every 8 hours, for three doses is preferred. The antibiotic can be discontinued after the dose on the first postoperative morning.

POSTOPERATIVE CARE

The Penrose drain is maintained for 3 to 4 days or until there is no sign of a mucous drainage. Respiration is maintained through a cuffed tracheostomy tube for at least 4 days to avoid allowing the patient to cough directly into the reconstructed larynx. Subsequently, the cuff can be deflated and if there is no indication of aspiration, the tracheostomy tube can be downsized to an uncuffed no. 4, which can be plugged to ascertain the adequacy of the reconstructed airway. If the patient can sleep comfortably with the tracheostomy tube plugged, it can be removed and the stoma allowed to close by secondary intention.

COMPLICATIONS

Complications may be encountered in patients undergoing vertical partial hemilaryngectomy. Most are preventable through careful planning and performance of the procedure. Certainly, the most commonly encountered early postoperative complication is infection. The wound is clean contaminated, which is the indication for perioperative prophylactic antibiotics. The drain should be maintained until there is no evidence of suppuration. Patients who have been previously treated with radiation therapy may on occasion retain fragments of avascular cartilage, but healing by secondary intention is the rule.

Another complication, which is not specific to this procedure, is accidental displacement of the tracheostomy tube. This can be catastrophic if the airway is completely obstructed by edema. Accordingly, traction sutures are placed above and below the tracheostomy site, and the tracheostomy tube should be sutured into place.

Prolonged decannulation is generally an indication of either persistent glottic edema or inadequate reconstruction of the lumen. Avoidance of unnecessary soft tissue reconstructions will reduce postoperative edema. Accordingly, I limit my reconstruction to the arytenoid and the anterior commissure; the defect in the vocal fold will heal by secondary intention and need not be otherwise reconstructed. Long-term airway stenosis reflects inadequate reconstruction; accordingly, successful epiglottopexy is essential. Secondary reconstruction of laryngeal stenosis is sometimes possible in previously unirradiated patients through the introduction of a laryngeal keel.

Dysphonia is to be expected following this procedure and should not be considered a complication.

RESULTS

Partial vertical hemilaryngectomy is a highly effective means of controlling limited glottic cancers. When margins are negative, it is reasonable to expect a 95% cure rate. Cervical metastases are exceptionally rare, and adjuvant radiation therapy is almost never needed.

Postoperative monitoring for recurrent cancer is accomplished most effectively through office flexible fiberoptic examination. The development of a small granuloma is common, especially if there are exposed sutures. These may become diagnostic dilemmas and require endoscopic sampling and suture removal. Patients with a good prognosis remain at risk for development of a second primary cancer and should remain under surveillance.

VPL in the setting of prior radiation therapy, which has failed to eradicate the cancer, represents a significant challenge inasmuch as the persistent cancer may be multifocal, thereby eluding detection by either the surgeon or the pathologist. Modern imaging cannot identify the last tumor cell; therefore, it is essential that the operation be tailored to the tumor that was present before radiation therapy. This, of course, is greatly facilitated if the surgeon had an opportunity to see the tumor before the patient underwent radiation therapy. Disease control in the setting of prior failed radiation therapy is accordingly compromised, but remains possible. Available data suggest that over 80% of persistent tumors after radiation are multifocal.

PEARLS

- Tracheostomy and resection should be carried out through two separate incisions.
- Perioperative antibiotic prophylaxis should be administered at the start of surgery.
- Careful localization of the mucosal extent of the tumor will facilitate accurate resection and maximum preservation of healthy tissue.

- Cartilage incisions should be made perpendicular to the plane of the cartilage.
- Precise separation of the tumor from the normal vocal fold is essential for clear margins.
- A new margin from the residual vocal fold should be sent for frozen section.
- Patients requiring resection of greater than one-third of the longer residual vocal fold require reconstruction.
- A cuffed tracheostomy tube should be maintained for 3 to 4 days after surgery.

PITFALLS

- Use of a suction drain will cause saliva to enter the wound.
- Failure to suture the anterior end of the longer vocal fold to the thyroid cartilage may lead to retraction and stenosis.

INSTRUMENTS TO HAVE AVAILABLE

- Power saw
- Headlight

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24 TRANSORAL LASER MICROSURGERY OF SUPRAGLOTTIC CANCER

Petra Ambrosch

INTRODUCTION

The treatment of supraglottic cancer may include surgery or radiotherapy, as single-modality therapy or combined treatment. If surgery is part of the treatment protocol, the open transcervical and the endoscopic transoral approach are available for access to the primary tumor. The open supraglottic laryngectomy was first described by Justo Alonso in 1947. The procedure consists of resecting the entire supraglottis including the epiglottis, the preepiglottic adipose tissue, and the ventricular folds together with the thyroid cartilage superior to the glottic plane. The conventional supraglottic resection may be extended posteriorly to include resection of the arytenoid, anteriorly to the base of the tongue and laterally to the piriform sinus.

With regard to these requirements, open supraglottic partial laryngectomy can be indicated for T1, T2, and selected T3 and T4 cancers. The management of the primary cancer has evolved over the last decades, and transoral approaches came into use. On condition that the supraglottis can be exposed adequately, cancers meeting the requirements for open supraglottic resections can be resected endoscopically as well. Vaughan from Boston was the first to describe supraglottic partial laryngectomy via transoral laser microsurgery. Steiner in 1979 used CO_2 laser technique for transoral endoscopic treatment of glottic and selected supraglottic cancers. Subsequently, Davis et al. and Zeitels et al. published the results of laser microsurgery in selected patients with supraglottic cancer. In recent years, the transoral approach became increasingly popular because of less morbidity and earlier and better swallowing rehabilitation compared to open supraglottic laryngectomy and simultaneous chemoradiation. T1 and T2 as well as selected T3 and T4 cancers were treated with this method.

HISTORY

Supraglottic cancers usually do not produce early symptoms. Patients may present with odynophagia, persistent dysphagia, otalgia, or chronic cough. Hoarseness, the typical early symptom of vocal cord cancer, can also occur with supraglottic cancer, though usually later in the disease state. Many patients notice a mass in the neck as a first sign of supraglottic cancer. Stridor and airway obstruction occur late.

PHYSICAL EXAMINATION

Physical examination must include fiberoptic laryngoscopy with adequate documentation. The spread of cancer within the larynx and to the adjacent organs, in particular piriform fossa and base of tongue, is determined. Special attention to the movement of the vocal cords is needed. A careful examination of the neck by palpation, ultrasound, and ultrasound-guided fine needle aspiration cytology is required to detect spread of cancer to the cervical lymph nodes. Computed tomography (CT) scans or magnetic resonance imagings (MRIs) of the neck are done to further determine the extent of the disease, both in the larynx and in the neck. This is followed by a direct laryngoscopy with biopsies.

Prior to surgery, a routine clinical examination including blood tests, chest radiography, electrocardiogram, and ultrasound of the abdomen is done. Pulmonary function tests may be useful in patients with preexisting chronic obstructive pulmonary disease. These tests are not routinely performed, since they are not predictive for postoperative outcomes. In my practice, the indication for transoral laser microsurgery is not influenced by the results of the pulmonary function tests. Second primary cancers, particularly in the head and neck region, the lung, and the esophagus, should be excluded preoperatively.

INDICATIONS

Prerequisite for a laser supraglottic laryngectomy is the adequate exposure of the supraglottis with a bivalved laryngoscope. Cancers of the epiglottis and/or ventricular fold(s) without infiltration of the preepiglottic adipose tissue (T1 and T2 tumors) and cancers with spread to the preepiglottic adipose tissue with mobile vocal folds (T3 tumors) are usually resectable with the laser. Cancers with impaired vocal cord mobility or vocal cord fixation due to spread of the cancer to the paraglottic space or fixation of the arytenoid cartilage can be resected along with parts of the vocalis muscle and/or the arytenoid cartilage. In more advanced cancers, parts of the base of tongue, piriform sinus, or one arytenoid cartilage can be included in the resection. The extent of laser resection is limited by the patient's ability to regain adequate swallowing function.

CONTRAINDICATIONS

Inadequate exposure of the supraglottis with a bivalved laryngoscope is a contraindication to endoscopic resection. Extensive infiltration of the soft tissues of the neck, bilateral extensive infiltration of the base of tongue, and cartilage destruction should also be regarded as contraindications to transoral laser microsurgery. Bilateral fixation of the vocal cord and/or arytenoid cartilage and excision of the cancer across the posterior commissure to the opposite arytenoid are also contraindications. These findings usually mandate a total laryngectomy.

PREOPERATIVE PLANNING

The routine use of CT scans is unnecessary in early supraglottic cancer, located at the free edge of the epiglottis or the ventricular fold. All other supraglottic cancers should be staged with either CT or MRI in order to detect any infiltration of the pre- and/or paraglottic space and cartilage invasion. MRI is particularly useful for detecting spread of submucosal spread of cancer and invasion of the preepiglottic adipose tissue. Imaging studies should always be performed prior to diagnostic microlaryngoscopy and biopsy.

Flexible Laryngoscopy and Staging Microlaryngoscopy

The accurate staging of a supraglottic cancer should include flexible laryngoscopy with adequate documentation. Detailed assessment of vocal cord mobility should be carried out. The extent of the cancer is determined with indirect and direct laryngoscopy. Angled rigid scopes are useful for evaluating the anterior commissure and the ventricles. Biopsy with histopathologic confirmation of cancer is necessary before a partial laryngeal resection is carried out. A carefully performed biopsy does not alter the clinical aspect of the tumor. Panendoscopy, staging microlaryngoscopy, and biopsy can be done at the same time as the definitive surgery, and we feel comfortable with frozen section confirmation of squamous cell carcinoma.

Therapeutic outcome of supraglottic cancer is influenced strongly by the presence of lymph node metastases. An accurate preoperative staging of the regional lymphatics must be performed. The lymph nodes of the neck are examined by ultrasound and ultrasound-guided fine needle aspiration biopsy. The majority of patients with supraglottic cancer are staged by the use of imaging techniques primarily indicated for staging of the primary cancer. With regard to the early detection of lymph node metastases, the use of MRI has added little to the diagnostic accuracy of contrast-enhanced CT.

SURGICAL TECHNIQUE

The patient is placed under general endotracheal anesthesia with paralytic agents. The carbon dioxide laser can be used with special endotracheal tubes like the Laser-Shield II (Xomed-Treace), an aluminum- and Teflon-coated silicone tube, or the Laser-Flex (Mallinckrodt), a spiral metallic tube with two cuffs. For years, we have been using the MLT Tube (Mallinckrodt) made of polyvinyl chloride, preferring a tube with a 6-mm inside diameter for most applications. The cuff of the tube is filled with air, and the endotracheal tube is secured in the left oral commissure if the surgeon is right handed. Ointment is placed in both eyes and the eyelids taped shut.

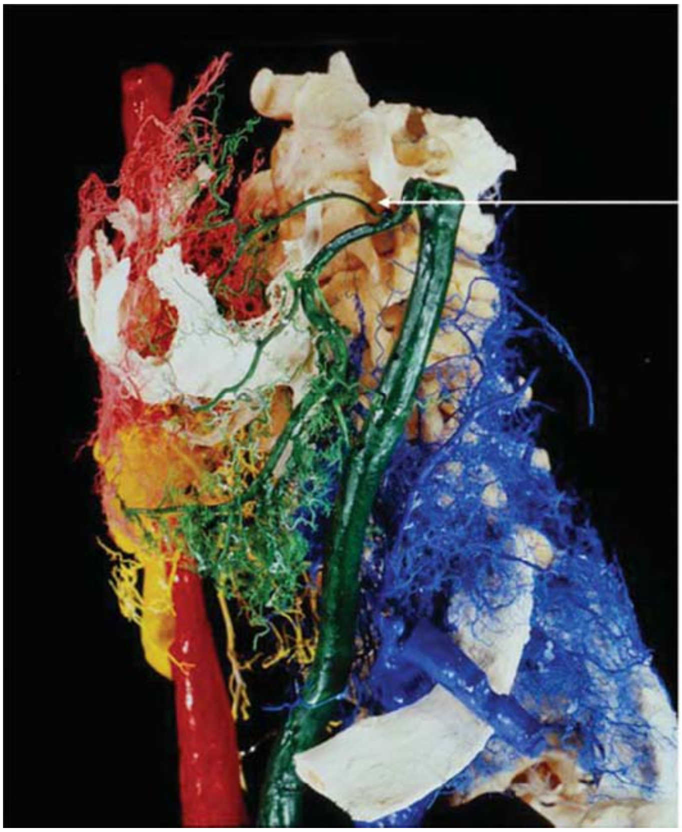

FIGURE 24.1 Corrosion specimen of the arteries of the neck. Four-color injection of methacrylate with preservation of the laryngeal skeleton. (Specimen of the scientific collection of the Institute of Anatomy of CAU Kiel, Klaws fecit.) (From Ambrosch P, Fazel A. Functional organ preservation in laryngeal and hypopharyngeal cancer. *GMS Curr Top Otorhinolaryngol Head Neck Surg* 2011;10:Doc02. [Epub 2012 Apr 26].)

A bivalved laryngoscope is inserted and correctly positioned. The upper blade of the laryngoscope is placed in the vallecula, and with the inferior blade, the endotracheal tube is pushed toward the posterior pharyngeal wall. After positioning of the laryngoscope, the blades are separated. The cuff of the endotracheal tube is covered with neurosurgical cottonoids moistened with saline. The patient's head is covered with a moistened towel to protect the skin of the face from accidental injury with the laser beam. Multiple repositioning of the laryngoscope is necessary during the operation in order to achieve good visualization of the cancer and the surrounding healthy tissue during the entire operation. After attachment of a smoke evacuation device to the laryngoscope, the first incisions can be made. The carbon dioxide laser and the micromanipulator are coupled to the operating microscope. The surgeon should carry out clean incisions making use of a narrowly focused laser beam and not several parallel incisions resulting in a wide incision.

The rare early cancers of the suprahyoid epiglottis or ventricular fold can usually be clearly exposed and excised en bloc. Cancers of the infrahyoid epiglottis are best removed piecemeal: The suprahyoid epiglottis is split in the midline and the mucosa is incised laterally in the pharyngoepiglottic fold. Before resection is carried out, both superior laryngeal arteries (Fig. 24.1) should be identified and ligated or clipped by the use of LIGACLIPS to prevent postoperative hemorrhage. After resection of the suprahyoid epiglottis, the laryngoscope is repositioned and the infrahyoid epiglottis exposed. Sagittal splitting of the infrahyoid epiglottis is continued until the thyroid cartilage above the anterior commissure is visible. The epiglottis is now separated from the ventricular fold. The thyroid cartilage is exposed laterally, and the infrahyoid epiglottis is removed together with the preepiglottic adipose tissue (Figs. 24.2 and 24.3). The internal perichondrium of the thyroid cartilage is raised with a microlaryngeal dissector and included in the resection. The thyroid cartilage is inspected to ensure tumor clearance. The false cords, the two vocal cords, and the arytenoid cartilages are preserved.

In cancers extending to the ventricular folds, incisions anterior to the arytenoid cartilages are placed and the folds resected. In cancers with infiltration of the paraglottic tissues at the glottic level, the resection is extended to the vocal fold uni- or bilaterally (Fig. 24.4). In locally advanced tumors, the resection can include portions of the base of the tongue, the piriform sinus, or one arytenoid cartilage.

The carbon dioxide laser coagulates vessels with a maximum diameter of 0.5 to 1 mm. Larger vessels were cauterized with a monopolar suction diathermy or with a coagulation forceps. Tracheostomy is generally not necessary due to the limited tendency for postoperative edema, even after extensive supraglottic laser resections. A tracheostomy

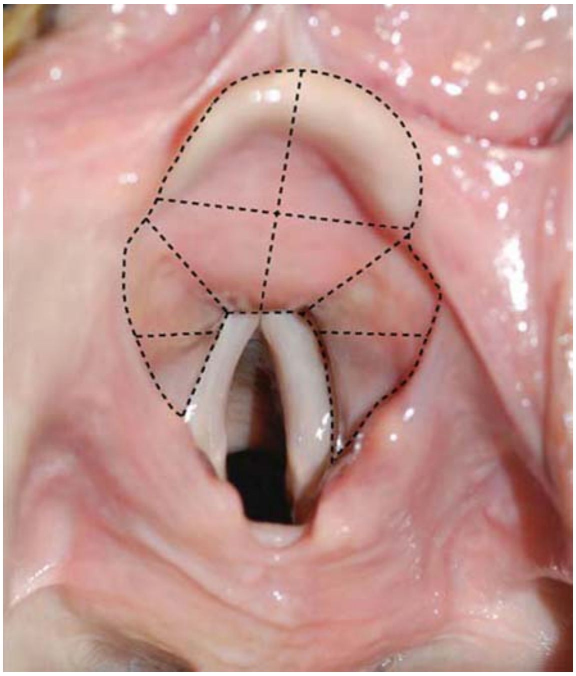

FIGURE 24.2
Anatomic specimen, nonfixed. The *dotted lines* show the resection in a case of a supraglottic cancer. (From Ambrosch P, Fazel A. Functional organ preservation in laryngeal and hypopharyngeal cancer. *GMS Curr Top Otorhinolaryngol Head Neck Surg* 2011;10:Doc02. [Epub 2012 Apr 26].)

should be considered in elderly patients with significantly impaired pulmonary function, in patients with a bleeding diathesis (e.g., anticoagulant medication, hemodialysis), or if heavy bleeding occurred during surgery.

Most supraglottic cancers are resected in multiple blocks. Marking the specimens precisely is essential for an adequate orientation for histopathologic examination. No matter which surgical methods are used, cancer-free resection margins must be achieved to prevent recurrence of the cancer. There is evidence that the risk of a local cancer recurrence is higher in patients with positive resection margins despite adjuvant radiotherapy. In case cancer-free resection margins have not been achieved after the first surgery, transoral laser re-resection is recommended.

POSTOPERATIVE MANAGEMENT

Patients receive a single dose of prednisolone before extubation. Prophylactic antibiotic treatment, usually with amoxicillin/clavulanate, is prescribed for 5 days. In contrast to open surgery, nasogastric tube feeding is only

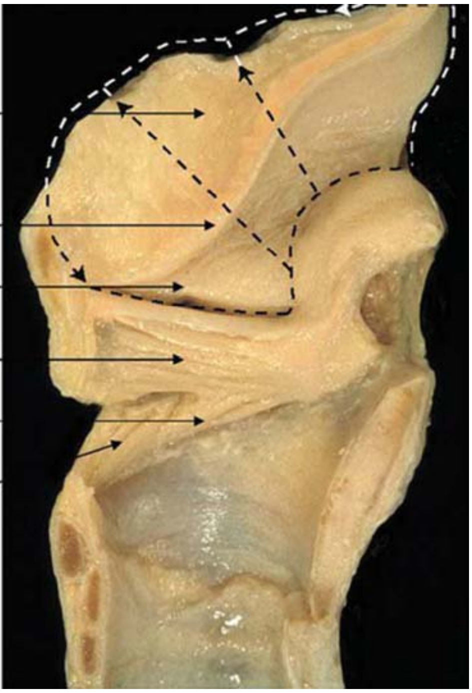

FIGURE 24.3
Right adult hemilarynx. Specimen of the scientific collection of the Institute of Anatomy of CAU Kiel. Photograph: B. Tillmann. The *dotted lines* show the resection in a case of a supraglottic carcinoma with complete resection of the epiglottis, the preepiglottic adipose tissue, and the false cord. (Specimen of the scientific collection of the Institute of Anatomy of CAU Kiel. Photograph: B. Tillmann.) (From Ambrosch P, Fazel A. Functional organ preservation in laryngeal and hypopharyngeal cancer. *GMS Curr Top Otorhinolaryngol Head Neck Surg* 2011;10:Doc02. [Epub 2012 Apr 26].)

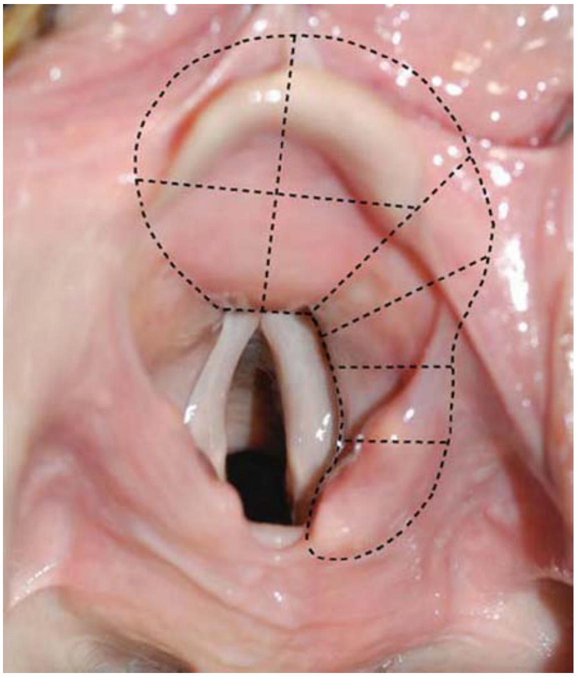

FIGURE 24.4 Anatomic specimen, nonfixed. The *dotted lines* show the resection in a case of a supraglottic cancer with the resection extended to the aryepiglottic fold and the arytenoid cartilage. (From Ambrosch P, Fazel A. Functional organ preservation in laryngeal and hypopharyngeal cancer. *GMS Curr Top Otorhinolaryngol Head Neck Surg* 2011;10:Doc02. [Epub 2012 Apr 26].)

necessary for the first few postoperative days. Oral feeding starts with semisolid food. Liquids can be attempted after semisolids are swallowed well.

COMPLICATIONS

The most common complication after transoral resection of supraglottic cancer is secondary endolaryngeal hemorrhage occurring with a frequency of 3% to 14%. The incidence is about equal for open procedures and laser microsurgery. However, every secondary bleeding after endoscopic surgery in a patient without a tracheostomy is a serious and potentially life-threatening complication due to the risk of aspirating blood. Nevertheless, bleeding from the base of the tongue or laryngeal remnant resulting in a fatal outcome has been described following open supraglottic laryngectomy as well. The formation of a supraglottic stenosis has been rare after transoral laser supraglottic laryngectomy. The rates are lower than after open supraglottic laryngectomy. This may be due to the fact that the thyroid cartilage is usually fully preserved. Clinically apparent chondritis is very rare, and the vocal folds are not immobilized by a tracheostomy, thus preventing stenosis.

ADJUVANT TREATMENT

Adjuvant radiotherapy is not indicated in patients with complete primary resection of the cancer and histopathologic cancer-free cervical lymph nodes. It is indicated in cases where microscopic residual tumor is assumed to be present at the primary site of the cancer despite re-resection (R1 resection), in patients with metastasis to more than one cervical lymph node and in cases of cervical lymph node metastases with extracapsular spread. Whether postoperative radiotherapy after open supraglottic laryngectomy has an adverse effect on laryngeal function is controversial. It was found that patients receiving postoperative radiotherapy after open supraglottic laryngectomy were more likely to require lifelong PEG tube feeding and were also more likely to have airway obstruction due to edema. Others found no increase in complication rates following adjuvant radiotherapy. I do not believe that the complication rate rises when postoperative radiotherapy is applied to the laryngeal remnant after transoral laser supraglottic resections.

RESULTS

Oncologic Results

Since the year 2000, an increasing number of studies on transoral laser microsurgery for supraglottic cancer have been published. For T1-T3 tumors, 5-year local control rates between 81% and 97% and larynx preservation rates between 91% and 97% have been reported. Studies retrospectively comparing open supraglottic

laryngectomy with transoral laser microsurgery found no statistically significant difference with respect to local control and disease-specific survival rates.

Functional Results

All authors who have reported on the transoral laser resection of supraglottic carcinomas agree that swallowing rehabilitation proceeds more quickly and has better outcomes than open supraglottic laryngectomy. The rate of secondary laryngectomy for persistent aspiration after open supraglottic laryngectomy is in the range of 3.5% to 12.5%. The incidence of postoperative aspiration and the time needed for swallowing rehabilitation vary with age, with general health condition, and with the extent of resection of the base of tongue and arytenoid cartilage. Due to considerable morbidity and postoperative functional impairment, open supraglottic laryngectomy often does not qualify as a treatment option, particularly in elderly patients with preexisting pulmonary disease.

On the whole, the functional results of laser microsurgery for supraglottic T1-T3 carcinomas are very favorable. Patients need nasogastric tube feeding normally for a few postoperative days. Aspiration is minimal and occurs in the early postoperative period only resulting in a reduced need for secondary tracheostomy and laryngectomy due to aspiration problems. Mechanisms contributing significantly to the recovery of swallowing function after supraglottic laryngectomy, either open or endoscopic, are the oropharyngeal transit time of the bolus, the closure of the airway at the laryngeal entrance, the position of the laryngeal remnant in relation to the base of the tongue, and the movement of the base of the tongue toward the posterior pharyngeal wall. Patients who regain these functions postoperatively meet the prerequisites for normal swallowing function.

I attribute the early and consistently successful swallowing rehabilitation to a variety of factors. The avoidance of tracheostomy, the integrity of the base of the tongue and pharyngeal muscles, and the preservation of the hyoid bone with the supra- and infrahyoid muscles contribute to a normal movement of the larynx during deglutition. However, at least one mobile arytenoid cartilage must be preserved in all operations, to enable functional closure of the larynx. In addition, O believe that preserving the superior laryngeal nerves is an important factor in sensory reinnervation.

PEARLS

- The safety rules for the use of lasers must be followed.
- Prior to surgery, thorough evaluation and treatment planning including flexible laryngoscopy, microlaryngoscopy, biopsy, and imaging studies are essential.
- Since the airway is not secured with a tracheostomy, meticulous hemostasis and an atraumatic surgical technique are required to avoid complications.

PITFALLS

- Lack of exposure of the tumor due to difficult anatomy may lead to incomplete resection of the cancer resulting in recurrence and loss of the larynx.
- Insufficient experience in transoral laser microsurgery may result in incomplete resection of the cancer.
- Rating functional aspects higher than oncologic principles may result in undertreatment and incomplete resection.
- Unnecessary removal of healthy tissues may result in functional deficits.

FIGURE 24.5
Bivalved laryngoscope. (Fa. Karl Storz, Tuttlingen, Germany.)

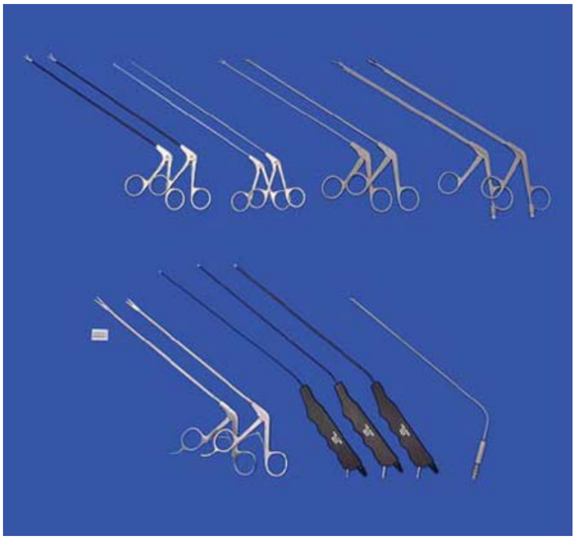

FIGURE 24.6 Microinstruments for transoral laser microsurgery. (Fa. Karl Storz, Tuttlingen, Germany.)

INSTRUMENTS TO HAVE AVAILABLE

- CO_2 laser
- Bivalved laryngoscope (Fig. 24.5)
- Laser-specific microinstruments needed for effective operations (Fig. 24.6)
- Grasping forceps
- Suction tube
- Coagulation forceps
- Insulated suction diathermy for suctioning and monopolar cautery
- Clip-applying forceps for the application of LIGACLIPS
- Protecting shields

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25 OPEN SUPRAGLOTTIC LARYNGECTOMY

Javier Gavilán

INTRODUCTION

In 1947, Justo M. Alonso, a well-known otolaryngologist from Montevideo, Uruguay, proposed a new surgical approach to cancer of the supraglottic larynx. This was the first description of what we call horizontal supraglottic laryngectomy (HSL).

Supraglottic laryngectomy is based on well-known embryologic, anatomic, and clinical findings. The supraglottis is embryologically derived from the buccopharyngeal anlage in the region of the third and fourth branchial arches, whereas the glottis and subglottis originate from the tracheobronchial anlage in the region of the fifth and sixth branchial arches. Despite this embryologic difference, no histologic or anatomical barriers have been demonstrated. However, an important consequence of this embryologic separation is the different lymphatic circulation that exists between the supraglottis and the rest of the larynx. This helps to explain the different clinical behavior of supraglottic cancer as compared to glottic cancer.

The advantages of supraglottic laryngectomy over total laryngectomy are preservation of natural speech and avoidance of a permanent tracheostomy. When compared to endoscopic approaches, it is technically easier, less time-consuming, and technologically uncomplicated. The main drawbacks of this open approach are the need for external incisions and temporary tracheostomy. When properly indicated and performed, its functional and oncologic results can be comparable to both total laryngectomy and endoscopic excision.

Several reasons may explain why this operation is less popular among surgeons in the United States and other Western countries:

- Supraglottic cancer is rather uncommon in the Anglo-Saxon population in which, glottic cancer is predominant.
- Partial laryngeal surgery has not been widely accepted in these countries, until recently.
- The procedure was popularized in Spanish.

In contrast, the operation was widely accepted among head and neck surgeons in Latin and Mediterranean countries. Nowadays, more than 60 years after its development, open HSL faces another challenge: The incorporation of endoscopic CO_2 laser calls open partial laryngeal surgery into question. For some surgeons, there is no reason to perform an open procedure when the same can be achieved through a less invasive, transoral operation. For others, open HSL is still a valid tool to remove cancer of the larynx. Since not all surgeons in all countries have access to technologic devices such as lasers, surgical microscopes or robotics. Under such circumstances, the golden rule for the treatment of patients with cancer of the larynx becomes crucial: *We do not have treatments of choice, but choices of treatment*. Open HSL is an important surgical technique among these options.

HISTORY

Unlike glottic lesions, supraglottic cancer seldom produces noticeable symptoms. This is due to the fact that the supraglottis is a rather silent area of the larynx, and cancer may grow undetected for long periods of time. Early diagnosis of supraglottic cancer is also difficult because the initial symptoms of these lesions are very nonspecific, including common complaints such as foreign body sensations with or without chronic cough, mild dysphagia and odynophagia, hemoptysis, or even otalgia.

The first manifestation of nearly 25% of patients with supraglottic cancer is a mass in the neck. This could be explained partly because of the delayed diagnosis for most patients with supraglottic cancer and partly because of the rich lymphatic drainage of the supraglottic region of the larynx. The widespread lymphatic distribution of the supraglottis also accounts for the high chances of bilateral and contralateral neck metastasis that these patients have.

Once the cancer grows, symptoms become more evident due to invasion of the vocal cords. Patients with advanced supraglottic cancer may present with hoarseness or stridor. Hemoptysis from erosion into a blood vessel may be the first symptom to call attention to a supraglottic cancer.

PHYSICAL EXAMINATION

Laryngoscopy and palpation of the neck are the two basic tools for a correct physical examination of patients with supraglottic cancer. Laryngoscopy can be performed with a laryngeal mirror, a flexible nasopharyngolaryngoscope, or a rigid telescope. Indirect mirror laryngoscopy has been widely surpassed by modern examination techniques with flexible or rigid endoscopes. However, in the lack of technologic devices, the mirror is still a valid tool to examine the endolarynx. Rigid telescopes have the advantage of better quality images but more frequently need topical anesthesia, especially in patients with a marked gag reflex. In my opinion, flexible endoscopes constitute the ideal tool for examination of the larynx. Most patients do not require any type of anesthesia and offer excellent images of the endolarynx. For supraglottic cancer, where accurate assessment of vocal cord mobility and infiltration is crucial, especially at the level of the anterior commissure, flexible endoscopes have the advantage of allowing close-up views, even around bulky cancers that prevent viewing the vocal cords from above. The use of the new chip flexible endoscopes—no longer *fiberoptic* endoscopes—yields even better quality images.

Palpation of the neck is very important in patients with supraglottic cancer. As mentioned above, a significant number of patients with supraglottic cancer have nodal metastasis at the time of diagnosis. Since cervical lymph node metastasis remains the most important prognostic factor for patients with cancer of the larynx, accurate palpation of the neck will contribute to the development of the best therapeutic approach to every patient with cancer of the supraglottis.

Other diagnostic tools, such as stroboscopy, are less useful in patients with supraglottic cancer than they are in patients with glottic lesions.

INDICATIONS

Despite 60% of all laryngeal cancers in our practice are located in the supraglottis, only 35% of them are suitable for supraglottic laryngectomy. The key to good oncologic and functional results is a thorough evaluation of the patient and the cancer, before supraglottic laryngectomy is undertaken.

Tumor Evaluation

Unimpaired vocal cord mobility is crucial for successful open supraglottic laryngectomy. The cancer must be confined to the supraglottic larynx, with bilateral vocal cord mobility and arytenoids that must be cancer free. Patients with normal vocal cord mobility may complain of throat pain, dysphagia, or odynophagia, but they should not have hoarseness.

The key structures to assess during physical and endoscopic examination are the arytenoids and the anterior commissure. Although it is unusual for supraglottic cancer with mobile vocal cords to invade the arytenoid(s), this fact must be well documented before surgery.

Open supraglottic laryngectomy can be considered for

- All T1 and T2 supraglottic cancers
- T3 supraglottic cancers with mobile vocal cords and limited extension to the preepiglottic space
- T4 supraglottic tumors with superficial invasion of the base of the tongue

Patient Evaluation

Patient age and pulmonary function are the key points to consider for open supraglottic laryngectomy. These two factors have been rigidly used in the past, where patients over 70 years of age were not considered candidates for open supraglottic laryngectomy. However, a more pragmatic approach is suggested today, focusing more on biologic rather than chronologic age. Although most patients are heavy smokers and have chronic bronchitis, this condition may sometimes be optimized preoperatively. Patients with compromised pulmonary function should not be considered for supraglottic laryngectomy.

The patient must be counseled that swallowing will be difficult postoperatively and rehabilitation will be more demanding than after total laryngectomy.

CONTRAINDICATIONS

Tumor Evaluation

Anterior commissure involvement is a contraindication to open supraglottic laryngectomy because the thyroid cartilage and the extralaryngeal soft tissues are usually invaded through the anterior commissure (Broyles ligament). In borderline cases, fine-cut laryngeal computed tomography (CT) or magnetic resonance imaging (MRI) scans may help with the evaluation of the paraglottic and preepiglottic spaces, as well as with the area of the anterior commissure.

When doubt still persists after clinical, endoscopic, and imaging tests, the final decision relies on the pathologic evaluation of the surgical margins.

Even though this may not be considered an absolute contraindication for open supraglottic laryngectomy, I never include one arytenoid or the pyriform sinus in the resection. The reason for this is the high rate of postoperative complications and unsatisfactory functional results that these patients manifest.

The same could be said about major resection of the base of the tongue as part of open supraglottic laryngectomy. The operation can be considered safe from a functional standpoint when the superior extension of the cancer does not reach the circumvallate papillae. If the resection needs to extend beyond this point, or the hypoglossal nerve has to be sacrificed, open supraglottic laryngectomy should not be attempted.

Patient Evaluation

Physiologic contraindications include severe and irreversible pulmonary disease. Neurologic diseases with swallowing problems and esophageal strictures also disqualify the patient for open supraglottic laryngectomy.

PREOPERATIVE PLANNING

Imaging Studies

Imaging techniques can be carried out to assess extensions of the cancer as well as to evaluate the status of the neck. Both CT and MRI scans can be used, but I consider CT scans to be more helpful. With regard to the primary tumor, the information provided by imaging studies may help to identify the limits of the cancer. However, precise identification of extension can only be achieved by means of physical examination as described above. Moreover, sometimes the feasibility of the operation can only be decided during surgery, once the larynx is opened and the limits of the tumor cancer are assessed under direct vision.

Positron emission tomography—computed tomography scan can be useful in demonstrating distant metastasis in selected patients with a bulky cancer and regional metastasis.

Biopsy

Biopsy of supraglottic cancer can be made under either local or general anesthesia. Laryngeal biopsy with traditional mirror technique or by means of a fiberoptic nasopharyngolaryngoscope is an office-based procedure that provides tissue samples for pathologic examination. It was the routine practice several decades ago, but nowadays is less frequently used.

The pros and cons of an independent laryngeal biopsy under general anesthesia must be carefully discussed with the patient. The main advantages of a biopsy procedure prior to definitive treatment are that it gives an accurate diagnosis, provides direct information about extension of the cancer, and allows detailed treatment planning to be discussed with the patient. The disadvantage of this approach is that the patient needs two different operations under general anesthesia to complete the treatment. For most of the patients, I prefer the "all-in-one" approach assuming that more than a supraglottic laryngectomy must be done if the tumor extends beyond

the expected limits. This is always the rule with more comprehensive type of partial laryngectomy. For this reason, all patients must sign an informed consent allowing the surgeon to proceed with a more extensive operation (i.e., total laryngectomy) should the findings exceed the estimates of preoperative margins.

Finally, the preoperative planning must include the ability to obtain frozen sections during the operation. To be oncologically sound, all partial laryngeal operations require intraoperative assessment of surgical margins. Since the inferior margins in open supraglottic laryngectomy can be as close as 1 mm, no doubts can exist at the end of the operation. This can only be achieved by means of a meticulous tissue sampling of all surgical margins from the patient side (not taken from the excised specimen), once the cancer has been removed.

SURGICAL TECHNIQUE

The procedure is performed under general anesthesia with endotracheal intubation. The patient is placed in the supine position with the shoulders elevated and the neck extended.

Skin Incision

The skin incision extends inferiorly from the mastoid tip along the anterior border of the sternocleidomastoid muscle, to a level just below the thyroid cartilage. After crossing the midline, the incision is extended upward, along the anterior border of the sternocleidomastoid muscle, to the level of the tip of the hyoid. If neck dissection is to be performed simultaneously, the incision is extended to the contralateral mastoid tip. The tracheostomy is placed through a separate horizontal incision at or below the level of the second tracheal ring.

The skin flaps are elevated in the subplatysmal plane. The superior flap is elevated above the level of the hyoid bone. Adequate exposure of the hyoid bone and strap muscles must be obtained.

Treatment of the Neck

Treatment of supraglottic cancer must include treatment of cervical lymph nodes. I usually perform bilateral simultaneous functional neck dissection, including levels II–IV, before the supraglottis is approached. Level IIB is dissected in the node-positive neck(s).

Skeletonizing the Larynx

Note: The following maneuvers are usually performed, approaching from the side of the tumor. For midline lesions, a right-sided approach will be easier for right-handed surgeons.

Supraglottic laryngectomy begins by dividing the strap muscles at the level of the hyoid bone (Fig. 25.1). If the cancer extends to the superior aspect of the epiglottis, the hyoid bone is included in the resection;

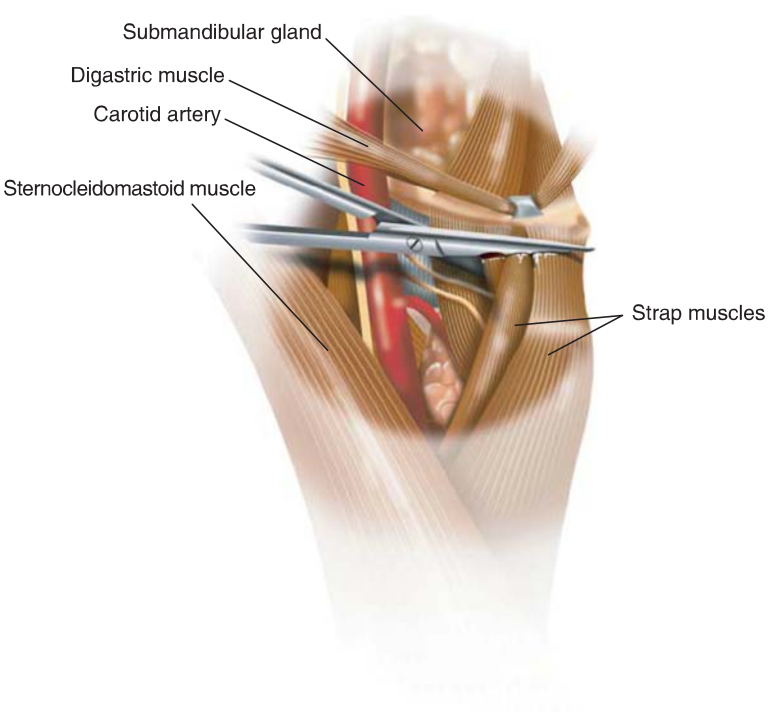

FIGURE 25.1
The strap muscles are sectioned immediately below the hyoid bone.

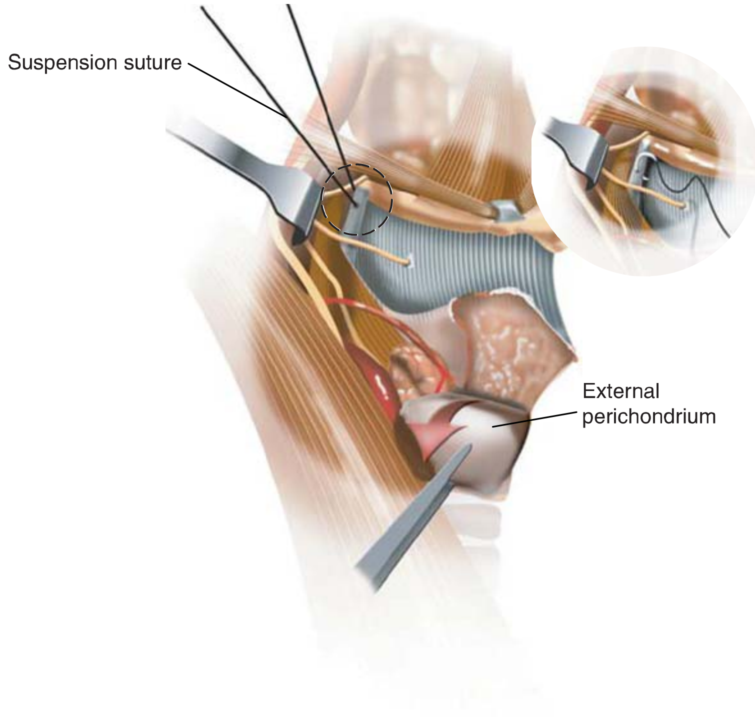

FIGURE 25.2 The external perichondrium of the thyroid cartilage has been reflected downward to the level of the vocal cords. The internal perichondrium is being dissected, taking care not to enter the paraglottic space. A suspension suture (see *circled enlargement*) is passed through the inferior end of the lateral thyrohyoid ligament. It will pull the laryngeal remnant superiorly against the base of the tongue during reconstruction.

otherwise, it is preserved. Once transected, the strap muscles are reflected inferiorly exposing the superior half of the thyroid ala. The attachments of the inferior constrictor muscle to the lateral border of the thyroid cartilage are transected. This maneuver exposes the greater horn of the hyoid bone and the upper half of the thyroid cartilage from the lateral border to the midline.

Using a scalpel, the external thyroid perichondrium is now incised along the superior rim and superior half of the posterior border. Pushing the thyroid ala from behind with a finger helps the dissection of the perichondrium. Using a periosteal elevator, the perichondrium is reflected inferiorly to the level of the vocal cords (Fig. 25.2). This level is located at the junction of the superior one-third with the inferior two-thirds of the thyroid cartilage. The inner perichondrium is also dissected from the internal surface of the thyroid cartilage (Fig. 25.2). Care must be taken to avoid entering the paraglottic space through overly aggressive force.

Suspension Sutures

A 2-0 polyglycolic acid suture is passed through the inferior end of the lateral thyrohyoid ligament (Fig. 25.2). It will be used as a suspension suture during pharyngeal reconstruction, bringing the laryngeal remnant closer to the base of the tongue.

Cartilage Incision

The superior third of the thyroid cartilage, along with a narrow strip of the contralateral side, is removed on the side of the cancer (Fig. 25.3). During this maneuver, the surgeon must stay just superior to the level of the vocal cords, to avoid injuring the anterior commissure. A small window created in the anterior midline, immediately above the cartilage cut, allows direct visualization of the vocal cords and ventricles (Fig. 25.4).

Preepiglottic Space Removal

To completely remove the preepiglottic space in a hyoid preserving approach, a subperiosteal dissection is performed along the inferior and posterior border of the hyoid bone until the mucosa of the vallecula is reached. The contents of the preepiglottic space are reflected inferiorly.

FIGURE 25.3
To approach the soft tissues of the larynx, the superior third of the thyroid cartilage and a narrow strip of the contralateral side are removed.

Pharyngotomy

The superior laryngeal artery and vein are identified, ligated, and divided. The internal branch of the superior laryngeal nerve is also identified and should be preserved if at all possible. However, it usually crosses the resection lines and must be sacrificed. In my experience, this does not carry an increased risk of functional disturbance in the postoperative period.

The pharynx is entered on the side opposite the tumor. For bilateral or midline lesions, the pharynx is entered on the surgeon's preferred side (usually right side for right-handed surgeons). The exact location of the pharyngeal opening—vallecula or lateral wall of the pyriform sinus—is decided according to the location of

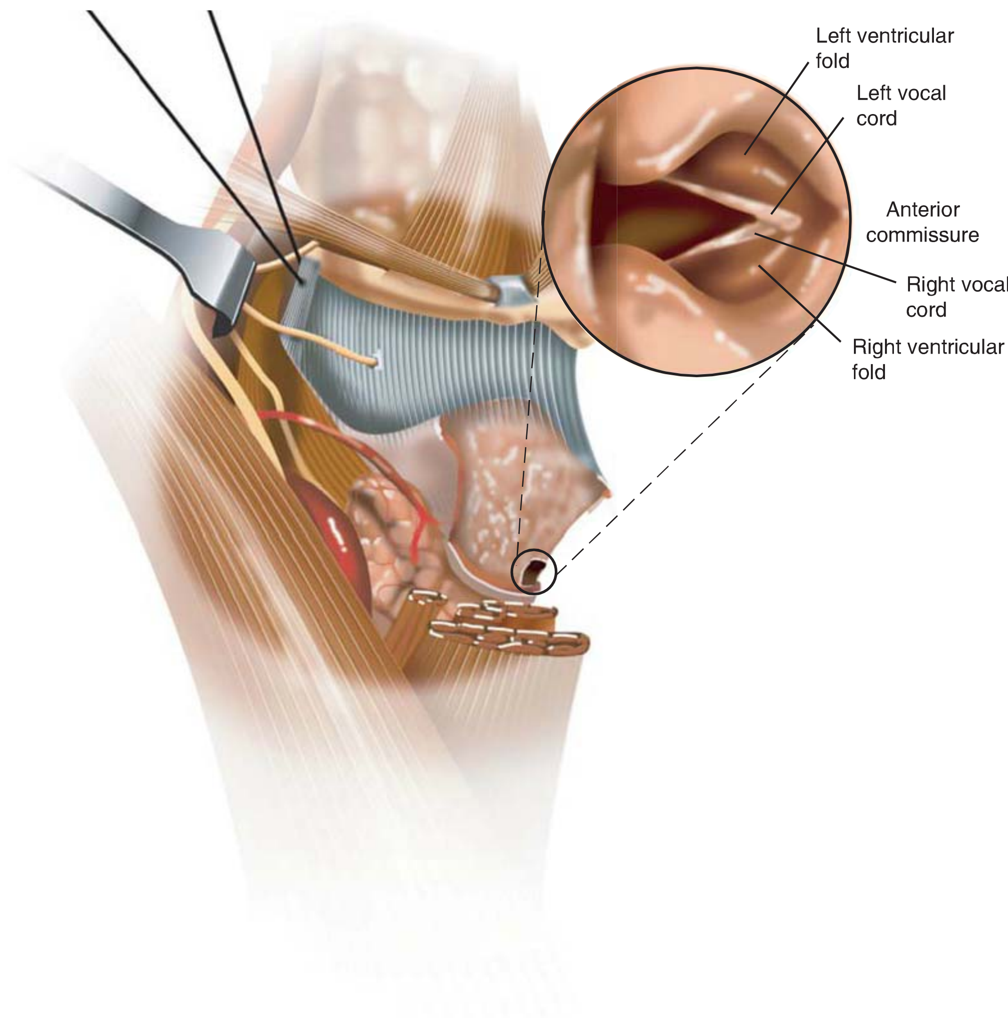

FIGURE 25.4
Through the small window created directly above the anterior commissure, the following structures can be identified: left ventricular fold, right ventricular fold, left vocal cord, and right vocal cord. AC indicates the anterior commissure (surgeon's view).

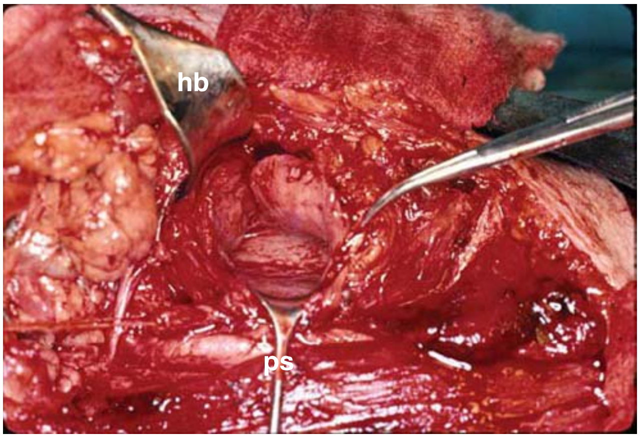

FIGURE 25.5 The pharyngotomy has been performed. To obtain a good view of the involved structures, the hyoid bone (hb) must be reflected superiorly and the mucosa of the pyriform sinus (ps) laterally.

the cancer. When possible, the pharynx is opened from the lateral wall of the pyriform sinus to the vallecula. By reflecting the hyoid bone superiorly and the mucosa of the pyriform sinus laterally, a good view of the epiglottis, endolarynx, vallecula, and the base of the tongue is obtained (Fig. 25.5). The following mucosal cuts should be performed under direct vision, allowing safe resection margins.

Resection of the Supraglottis

The removal of the supraglottic structures begins with the inspection of the endolarynx through the anterior commissure using a headlight. The scissors are then introduced through the window created in the anterior midline, just above the anterior commissure. One blade of the scissors is put in the ventricle and the other in the external soft tissues of the larynx (Fig. 25.6A). The incision runs from the anterior commissure to the vocal process of the arytenoid, along the floor of the ventricle. No false vocal cord should be left behind. All incisions should be made under the direct vision of the operating surgeon.

A second incision is made to join the lateral pharyngotomy with the ventricular incision (Fig. 25.6B). This incision runs across the aryepiglottic fold, close to the anterior surface of the arytenoid cartilage, to join the first incision at the level of the vocal process of the arytenoid (Fig. 25.7).

These two incisions allow the complete separation of the supraglottis from the glottis on one side of the larynx. Now the supraglottis can be rotated medially, opening the larynx like a book (Fig. 25.8). This exposes the opposite side of the endolarynx, where the resection can be completed under direct vision. An incision is made along the anterior surface of the arytenoid, transecting the aryepiglottic fold (Fig. 25.9). Supraglottic resection is completed by incising the floor of the ventricle from the anterior commissure to the vocal process of the arytenoid.

In supraglottic laryngectomy, microscopically free margins 1-2 mm are considered oncologically sound at the inferior margin of the resection. Frozen sections in this area are essential to document complete removal of the cancer.

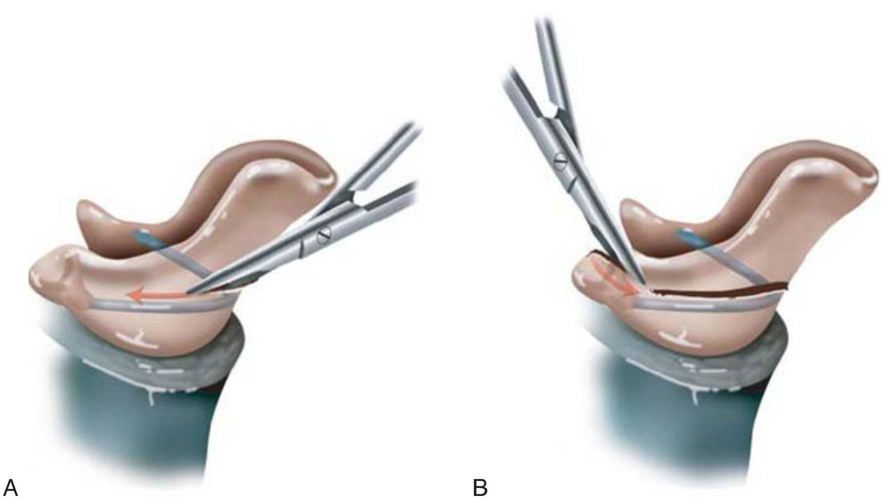

FIGURE 25.6 **A:** Removal of the supraglottis begins with a first incision running along the superior surface of the vocal cord, from the anterior commissure to the vocal process of the arytenoid. **B:** The second incision is made across the aryepiglottic fold, to join the first incision at the level of the vocal process of the arytenoid.

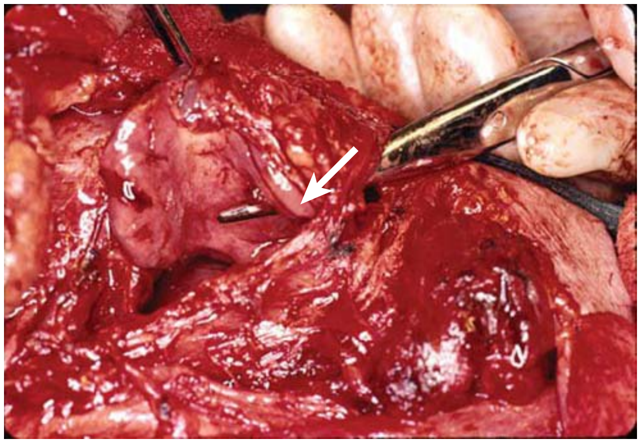

FIGURE 25.7
The first incision has been made from the anterior midline along the superior surface of the vocal cord. The second incision runs across the aryepiglottic fold and anterior surface of the arytenoid. A small strip of tissue (*arrow*) must be sectioned to complete the resection on the right side.

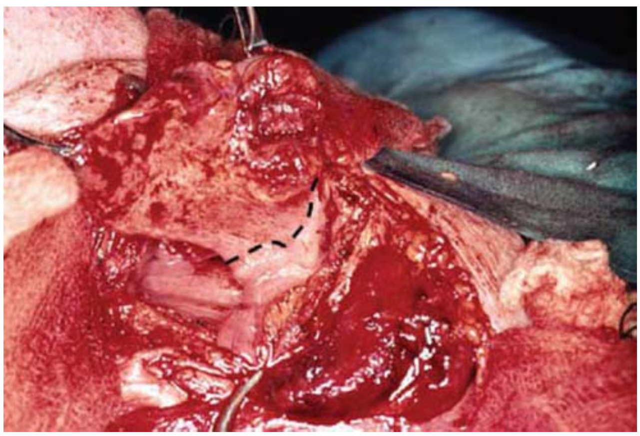

FIGURE 25.8
The supraglottis is rotated medially allowing the visualization of the resection lines on the left side of the larynx (*dashed line*).

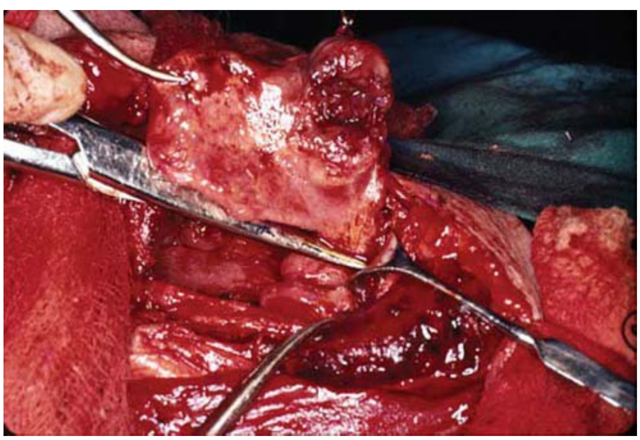

FIGURE 25.9
Section of the aryepiglottic fold, along the anterior surface of the arytenoid, on the left side.

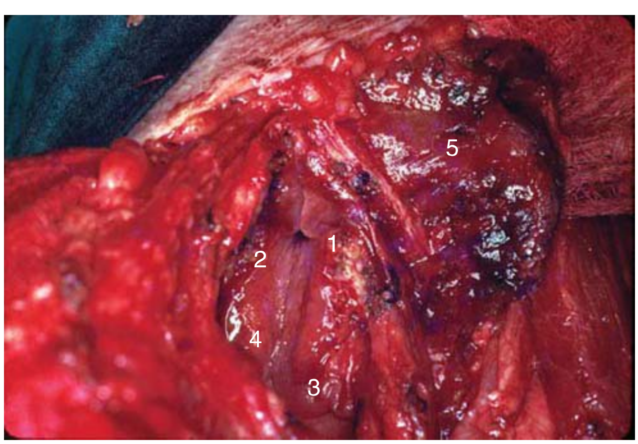

FIGURE 25.10
View of the laryngeal remnant after the supraglottis has been removed. *1,* Right vocal cord; *2,* left vocal cord; *3,* right arytenoid cartilage; *4,* left arytenoid cartilage; *5,* strap muscles.

Once the supraglottis has been completely removed, a perfect view of the vocal cords and arytenoids is obtained (Fig. 25.10).

Reconstruction

Reconstruction begins by closing the pharyngotomy without tension. The raw surface of the arytenoids is not covered with mucosal flaps to avoid permanent edema. Care must be taken to avoid pharyngeal stenosis that will produce swallowing problems and aspiration. The anterior–lateral portion of the pharynx is reconstructed using the strap muscles and the thyroid perichondrium.

After a nasogastric feeding tube is placed, a series of 3-0 polyglycolic acid sutures are placed through the superior end of the strap muscles and thyroid perichondrium. These sutures are passed around the hyoid bone and deep into the base of the tongue. Four or five sutures are enough. Each suture is placed but not tied. Once they are all in place, they are tied in sequence after flexing the patient's head. The suspension suture is placed through the inferior aspect of the thyroid cartilage, pulling the laryngeal remnant anterior and superior toward the base of the tongue.

The pharyngotomy is closed with interrupted 3-0 polyglycolic acid sutures. I do not routinely perform cricopharyngeal myotomy as part of standard supraglottic laryngectomy. The neck is closed over two large suction catheters, and a cuffed tracheostomy tube is placed. The inferior skin flap must be sutured to the strap muscles to isolate the airway from the neck.

POSTOPERATIVE MANAGEMENT

The cuffed tracheostomy tube is left in place for 2 or 3 days and is then replaced by a fenestrated uncuffed tube. Six or seven days after the operation, the patients start swallowing their saliva. Swallowing training begins on the 9th or 10th postoperative day. Semisolid food (e.g., banana, yogurt, puddings) is preferred at the beginning because thin liquids will spill more easily into the larynx.

The feeding tube is removed when the patient is able to eat without much trouble. The tracheostomy tube is removed as soon as the patient is able to breathe with the tube corked for more than 48 hours. If postoperative adjuvant therapy is planned, the tracheostomy can remain until the end of radiation therapy.

COMPLICATIONS

Supraglottic laryngectomy requires more effort, cooperation, and motivation from the patient than does total laryngectomy. It takes time and patience both from the patient and the surgeon to overcome the most frequent problems of the operation. Aspiration and secondary pneumonia are the major complications. The best way to avoid them is by only selecting patients for supraglottic laryngectomy who are likely to overcome expected pulmonary complications. It is better not to perform a supraglottic laryngectomy rather than to convert it to a total laryngectomy because of aspiration.

Obstruction of the airway may be caused by stenosis or by redundant, edematous mucosa that acts like a valve obstructing the glottis. Both problems are usually caused by retained tissue in the area of the false vocal cords. Airway obstruction due to edema may also be found in patients after postoperative radiation, which is the reason for not removing the tracheostomy in patients undergoing postoperative radiation therapy.

RESULTS

When properly chosen and performed, open supraglottic laryngectomy provides excellent oncologic and functional results. The following data summarize our results with the operation (see Suggested Readings: Herranz et al. *Ann Otol Rhinol Laryngol* 1996;105:18–22).

A total of 110 patients treated with open supraglottic laryngectomy were followed until death or for a minimum of 36 months. Local control 3 years after surgery was 94.6%. The 3-year actuarial survival according to T stage was 75% for T1, 78% for T2, 87% for T3, and 80% for T4. Neck recurrences were diagnosed in 18 patients (16.4%). The overall 3-year actuarial survival was 78%. Five years after the operation, 72.6% of the patients were still alive. Ten patients died of unrelated causes with no evidence of disease.

In 52% of the patients, hospital stay was <20 days, and in 16%, hospitalization was longer than 25 days. The feeding tube was removed within the first 3 weeks in 51% of the patients. Only 7% of the patients needed feeding tube for more than 35 days.

One year after the operation, aspiration was not a problem for 49% of the patients. In 42% of the patients, minor occasional aspiration was present when drinking, and only 8% of the patients complained of frequent aspiration 1 year postoperatively. One patient required total laryngectomy 3 months after surgery because of severe aspiration.

Decannulation was possible in 94.5% of the patients. Three patients were not decannulated because of laryngeal stenosis and three because of arytenoid edema. Reopening of the tracheostomy was necessary in two

patients during postoperative radiotherapy. Five more patients required direct laryngoscopy to remove arytenoids edematous mucosa to obtain a safe glottic airway.

PEARLS

- In spite of a thorough clinical and endoscopic examination, the feasibility of supraglottic laryngectomy may not be obvious until the larynx is opened and the margins are visually and pathologically inspected. The patient must be aware of this fact and all options must be discussed and agreed to prior to surgical management especially conversion to total laryngectomy.
- Removal of the superior part of the thyroid ala on one side is required to approach the soft tissue of the larynx from the outside. This is not an oncologic but a technical step of the operation. Some surgeons remove the superior part of both thyroid alae. In my hands, this results in more fibrosis at the level of the anterior commissure producing anterior vocal cord webbing.
- Creating a small window in the anterior midline above the level of the anterior commissure allows direct visualization of the anterior and inferior margins of resection and helps while making the incision along the floor of the ventricle under direct vision.
- Partial laryngeal surgery without frozen sections is risky (for the patient). All tissue samples must be taken from the patient's side, not from the specimen side.
- Use the suspension suture with the lateral thyrohyoid ligament to elevate and fix the laryngeal remnant during reconstruction at the end of the operation. This helps deglutition and reduces the chances for aspiration in the early postoperative period.
- Remove shoulder pillows before the reconstruction begins, and flex the patient's head to avoid tension when suturing the strap muscles.

PITFALLS

- The Anterior commissure stenosis may occur if the anterior commissure is damaged while removing the thyroid cartilage.
- Incomplete removal of the false cords may compromise complete tumor resection and will delay decannulation. Any remaining portion of false cords must be removed since mucosal remnants will result in synechiae and edema.
- Covering the raw surface of the arytenoids with mucosal flaps results in a higher risk of postoperative arytenoid edema.

INSTRUMENTS TO HAVE AVAILABLE

- Few unique instruments are needed for the operation.
- The usual instruments for any neck procedure could be complemented with strong scissors and bone cutting scissors for the section of the thyroid cartilage.
- Feeding tubes and tracheostomy tubes in different sizes should be available at the end of the operation.

SUGGESTED READING

Alonso JM. Conservative surgery of cancer of the larynx. *Trans Am Acad Ophthalmol Otolaryngol* 1947; 51:633–642.

Herranz J, Martínez-Vidal J, Gavilán J. Horizontal supraglottic laryngectomy: modifications to Alonso's technique. *Oper Tech Otolaryngol-Head Neck Surg* 1993;4:252–257.

Herranz J, Gavilán J, Martínez Vidal J, et al. Supraglottic laryngectomy: functional and oncologic results. *Ann Otol Rhinol Laryngol* 1996;105:18–22.

Morales-Angulo C, Val-Bernal F, Buelta L, et al. Prognostic factors in supraglottic laryngeal carcinoma. *Otolaryngol Head Neck Surg* 1998;119:548–553.

Ferlito A, Shaha A, Gavilán J, et al. Is radiotherapy recommended after supraglottic laryngectomy? *Acta Otolaryngol (Stockh)* 2001;121:877–880.

26 SUPRACRICOID PARTIAL LARYNGECTOMY

Ollivier Laccourreye

INTRODUCTION

The supracricoid partial laryngectomy (SCPL) is an important surgical option for patients with cancer of the larynx. The literature has demonstrated superior oncologic results, in terms of local control, when SCPLs are used for selected "early" endolaryngeal cancer (glottic, supraglottic, or transglottic in origin) when compared to transoral laser microsurgery, vertical partial laryngectomy, or radiation therapy as well as a valid alternative to chemoradiation protocols and total laryngectomy in the face of selected "intermediate-advanced" cancer of the larynx. Yet despite a wide resection of the endolaryngeal structures including both vocal cords and the thyroid cartilage, patients undergoing SCPLs maintain their own voice, normal swallowing, and no permanent tracheostomy.

Supracricoid partial laryngectomy includes three procedures: the cricohyoidopexy (CHP), cricohyoidoepiglottopexy (CHEP), and the tracheocricohyoidoepiglottopexy designed to resect selected glottic supraglottic and transglottic cancer while achieving phonation respiration and swallowing without the need for permanent tracheostomy, gastrostomy, or voice prosthesis. Currently more than 250 scientific reports from more than 15 countries document the worldwide diffusion and current use of the SCPL by numerous surgeons.

HISTORY

Patients who might be candidates for SCPL must be carefully evaluated for oncologic, functional, and wound-healing considerations. A patient with a large cancer with dyspnea or swallowing dysfunction is not an ideal candidate. Since all patients experience some temporary aspiration postoperatively, moderate to severe chronic obstructive pulmonary disease (COPD) should be considered a discrete contraindication. Formal pulmonary function testing is not usually needed. In fact, a commonly used assessment is the "step test." If the patient has adequate pulmonary reserve to walk up two flights of stairs, then a favorable postoperative outcome is expected. While poor pulmonary function places patients at risk for postoperative pneumonia, other illnesses that affect the microcirculation such as lupus, diabetes mellitus, or history of radiation therapy place the patient at risk for wound-healing complications.

Patients who are candidates for SCPL must be carefully evaluated to determine their ability to undergo a rigorous postoperative rehabilitation. Thus, as part of the clinical history and discussion of postoperative recovery, the surgeon should provide realistic expectations for both voice outcomes and the rigor of postoperative rehabilitation.

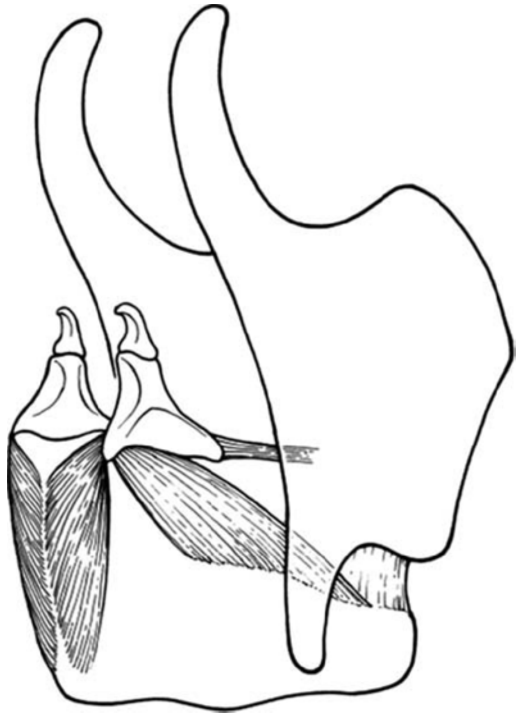

FIGURE 26.1
The SCPL hinges on the concept of the CA unit as the fundamental unit of laryngeal function. The CA unit is formed by the posterior and lateral CA muscles, the cricoid and arytenoid cartilages, and the nerves that supply sensory and motor function, the superior and inferior laryngeal nerves.

PHYSICAL EXAMINATION

Thorough evaluation of the larynx is paramount in preoperative selection and relies upon careful clinical examination, endoscopic evaluation, and imaging, usually computed tomography (CT) scan. The goal is to define precisely the site of origin of the cancer, to evaluate the spread of the cancer and laryngeal mobility, and to search for potential oncologic contraindications. Separate analysis of the motion of the vocal cord and arytenoid cartilages must be performed. All components of the “cricoarytenoid” unit (Fig. 26.1) should be uninvolved and have normal function. Direct laryngoscopy with magnification under apnea and no endotracheal tube present allows for the best evaluation of the status of the commissures (anterior and posterior), ventricles, and laryngeal surfaces of the epiglottis. Fine-cut CT scan of the larynx allows for precise determination of the status of the preepiglottic space, infraglottis, and cartilages. Patients with cancer arising from the true vocal cords (glottis) are candidates for a CHEP, while those with cancer considered as transglottic or supraglottic in origin as well as cancers from the anterior commissure are best managed with a CHP.

Finally, the neck is evaluated for adenopathy. Early involvement may be detected in this manner. Ipsilateral concurrent neck dissection should be considered for T3 carcinoma. Palpation of the cricothyroid and thyrohyoid membranes as well as thyroid and cricoid cartilages searches for firmness or tenderness indicating invasion by cancer.

INDICATIONS

Primary Surgery

- SPCL for T1b-3 cancer (glottic, transglottic, or supraglottic in origin) of the endolarynx
- Salvage surgery as a result of radiation failure for endolaryngeal cancer

CONTRAINDICATIONS

General

- Inability to undergo major surgery
- Respiratory insufficiency (inability to climb two flight of stairs without shortness of breath)
- Major swallowing impairment (neurologic disease, stroke)
- Advanced age by itself is not a contraindication, but in patients above 75 years of age, swallowing, pulmonary, and mental functions must be carefully evaluated.

Tumor Extent

- Cancer arising from the *epilarynx*. The epilarynx also called the laryngeal margin is the junction zone between the supraglottic larynx and the other regions: the oropharynx anteriorly and the hypopharynx laterally.
- Cancer originating from the subglottic region
- Involvement of inter arytenoid space or posterior commissure
- Mucosal involvement of both arytenoid cartilages
- Subglottic extension reaching the superior border of the cricoid cartilage
- Invasion of the hyoid bone and/or cricoid cartilage
- Major invasion of the preepiglottic space (bulging vallecula or thyrohyoid membranes)
- Fixation of the arytenoid cartilage
- Extralaryngeal spread of cancer

SURGICAL TECHNIQUE

Exposure

The bed is turned 180 degrees from the anesthesia machine. The neck is slightly extended. The skin incision begins one mastoid tip to the other mastoid tip in a standard "utility flap" placed about 2-cm cephalad from the sternal notch and then extending laterally. Later in the procedure, the tracheostomy will be placed through the central portion of this incision. If a single or bilateral neck dissection is planned, this incision is extended toward the mastoid tip. A broad-based subplatysmal flap is then raised to about 1 cm above the hyoid bone. The linea alba (midline raphe) is incised, and the central compartment lymphatics from the hyoid bone to the thyroid isthmus are removed. If suspicious lymph nodes are encountered, they are sent to pathology for frozen section analysis. Lymph nodes positive for cancer at this level should lead to the completion of bilateral levels II–III neck dissection. The thyroid isthmus is identified and divided. Inferior to the thyroid, the pretracheal fascial plane is gently dissected with blunt digital manipulation, and a cervicomediastinal release of the trachea is performed, ideally down to the level of the carina. It is critical that this finger dissection is performed with care, staying in the midline overlying the anterior wall of the trachea, to avoid devascularizing the lateral or posterior blood supply of the trachea.

The larynx is now released. The anterior jugular veins are ligated and transected. The sternohyoid and thyrohyoid muscles are divided along the superior edge of the thyroid cartilage. The sternothyroid muscles are then divided at their insertion along the oblique line of the thyroid cartilage, and the middle laryngeal vessels are ligated and transected. During these maneuvers, care is taken not to extend the dissection beyond the lateral edge of the muscle to avoid injury to the superior laryngeal neurovascular pedicle (in the thyroid membrane) and not to harm the underlying vessels of the upper lobe of the thyroid gland. The larynx is then rotated to expose the constrictor muscles. The pharyngeal constrictors are incised along the lateral edge of the thyroid cartilage. The inner perichondrium of the pyriform sinus is deflected bilaterally from the thyroid alae, as in a total laryngectomy. The cricothyroid joint is disarticulated, bilaterally with a sharp Freer elevator, taking care not to harm the underlying/recurrent laryngeal nerve.

Resection

A horizontal midline cricothyrotomy is performed at the superior edge of the cricoid cartilage. This maneuver allows the surgeon to evaluate the inferior extent of the cancer. The endotracheal tube is removed from the mouth, and a fresh anode tube is placed through the cricothyrotomy to help with visualization and resection of the cancer.

For CHEP, a transepiglottic laryngotomy is performed by a median horizontal incision through the preepiglottic space and infrahyoid epiglottis just above the petiole, placed at the superior border of the thyroid cartilage. For CHP, the hyoepiglottic ligaments (median and lateral) are transected at the level of their insertion along the inferior border of the hyoid bone. This maneuver drops the preepiglottic space and provides visualization of the mucosa of the vallecula. The mucosa is then incised at its junction with the base of the tongue.

The surgeon then moves to the head of the table to insure good visualization of the surgical field. Using an Allis clamp, either the petiole of the epiglottis (CHEP) or the tip of the epiglottis (CHP) is grasped. Resection then follows by transection of the false vocal cord (CHEP) or aryepiglottic folds (CHP). Scissors or monopolar cautery is used to incise down to just superiorly and anteriorly to the body of the arytenoid cartilage on the noncancer-bearing side. Transection ends at the superior border of the cricoid cartilage.

This vertical transection is then connected with the median cricothyrotomy. Anteriorly, the cricothyroid muscle and infraglottic mucosa are transected at the superior border of the cricoid cartilage with the use of fine scissors or the electrocautery knife. The thyroid cartilage is then grasped between both hands and broken apart

as if the surgeon were opening a book. This allows the surgeon to rotate the specimen along the most involved side and to directly visualize the cancer.

Based on the extent of the cancer, as well as assessment preoperatively of laryngeal mobility (arytenoid cartilage and true vocal cords), a decision is now made regarding whether or not the arytenoid cartilage on the cancer bearing side will be removed. Resection of the arytenoid cartilage allows the surgeon to completely resect the paraglottic space, including the lateral cricoarytenoid (CA) muscle and overlying cricothyroid muscle. If the arytenoid cartilage is resected, the interarytenoid muscle, posterior arytenoid mucosa, and corniculate cartilage are spared to allow for creation of a neoarytenoid that will be useful to reduce postoperative aspiration. In CHEP, the ventricles must be inspected bilaterally to ensure that no mucosa is left behind (transection of Morgagni ventricle). This prevents postoperative formation of a laryngocele.

Reconstruction

Before impaction (the pexy), the remaining arytenoid cartilage(s) must be repositioned; transection of the thyroarytenoid muscles leads to a posterior slide and swing of these structures (Fig. 26.2A). To reposition the arytenoids, one or two Vicryl 3-0 sutures are set at the anterior aspect of the cartilage above the vocal process and sutured through to the cricoid cartilage anteriorly (Fig. 26.2B and C). When both arytenoids are spared, the suture should be tied to the lateral portion of the cricoid to open the neoglottis. When one arytenoid has been totally resected, the suture for the remaining arytenoids should be placed to the anterior arch of the cricoid cartilage to reduce the gap created by the resection of the contralateral arytenoids (Fig. 26.2B and C). Also, in such cases, the completion of the corniculate flap, using the preserved retroarytenoid mucosa and spared corniculate cartilage on the side of the resected arytenoids, will create a neo-nonmobile arytenoid, which reduces the risk of aspiration (Fig. 26.2B and C).

The tracheostomy must be performed and aligned with the skin incision allowing for easy recannulation if postoperative respiratory problems occur after removal of the tube. To do so, the sutures that are placed for

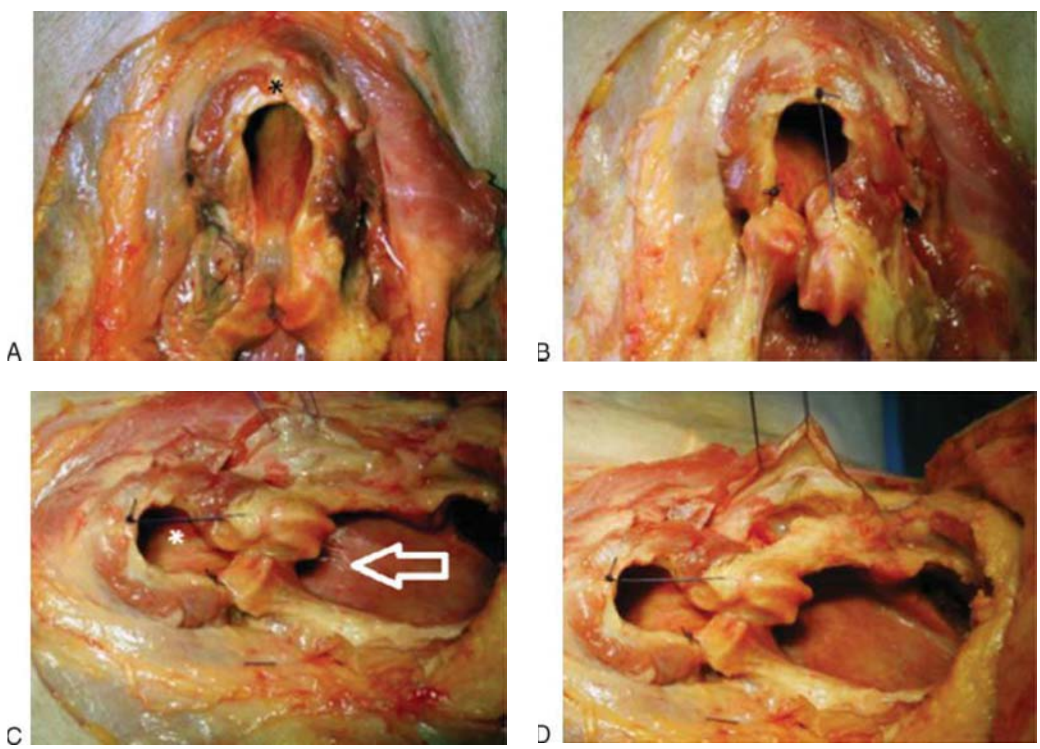

FIGURE 26.2 **A:** Resting position of right and left arytenoid cartilages following SCPL with partial sacrifice of left arytenoid. The anterior cricoid arch is indicated by the *asterisk*. **B:** Creation of buttress with left corniculate cartilage on the cricoid cartilage with more anterior rotation of right arytenoid in the setting of an arytenoid resection. Note anterior rotation with closure of glottis and creation of a hypopharyngeal inlet. **C:** Placement of sutures for repositioning of the pyriform sinus. (The *asterisk* denotes the laryngeal lumen, the *arrow* the pharyngoesophageal lumen.) Note two sutures in the inferior constrictor muscle with its attached fascia and visible perichondrium of the thyroid cartilage. **D:** Creation of lateral pharyngeal gutter for entry into pyriform sinus by repositioning inferior constrictor anteriorly. (From Holsinger FC, Laccourreye O, Weinstein GS, et al. Technical refinements in the supracricoid partial laryngectomy to optimize functional outcomes. *J Am Coll Surg* 2005;201:809–820, with permission.)

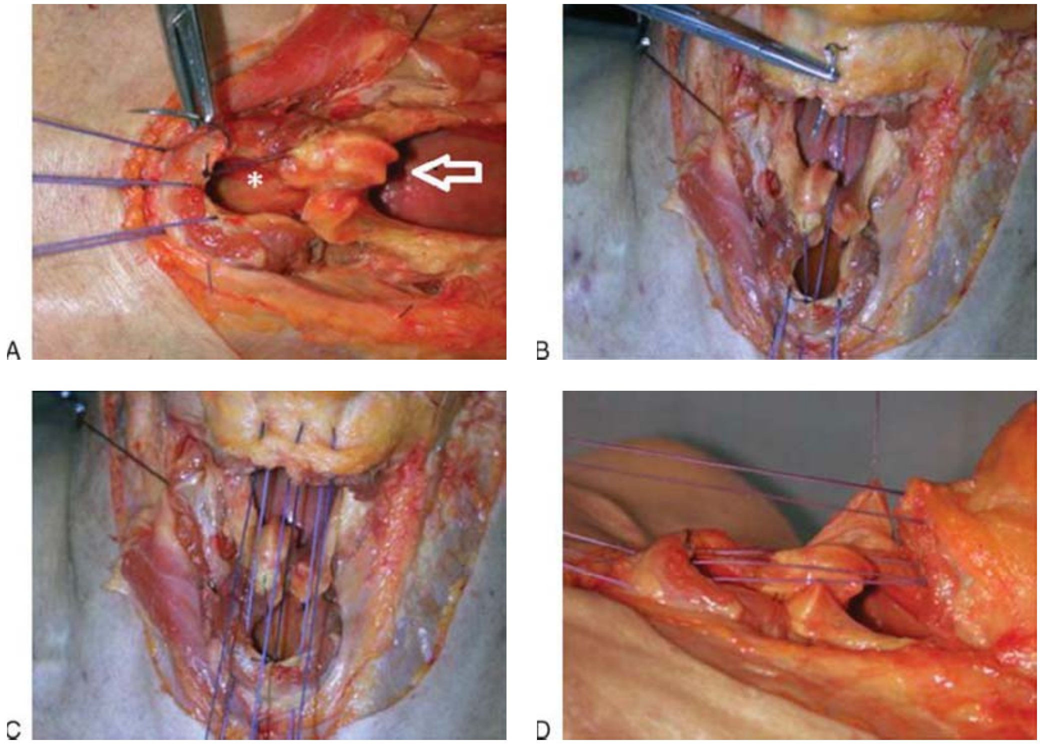

FIGURE 26.3 **A:** Submucosal, symmetric placement of three sutures in the cricoid cartilage for impaction (*asterisk*: laryngeal lumen; *arrow*: pharyngoesophageal lumen, with *arrow* pointing caudally). **B:** Placement of center suture first in SCPL–CHP through the base of the tongue around the hyoid and back under the remnant of the sternohyoid and thyrohyoid. **C:** Symmetric placement of three sutures prior to cricohyoid compaction. **D:** Lateral view prior to cricohyoid impaction with pyriform repositioning. (From Holsinger FC, Laccourreye O, Weinstein GS, et al. Technical refinements in the supracricoid partial laryngectomy to optimize functional outcomes. *J Am Coll Surg* 2005;201:809–820, with permission.)

impaction are approximated, and the head of the patient is placed into a normal or flexed position (from the previously extended position). The endotracheal tube is removed and the incision in the trachea is performed, at a level aligned with the skin. Ventilation is then performed through the tracheostomy. For a CHP, the larynx is approximated by suturing the base of the tongue and hyoid bone to the cricoid cartilage. For the CHEP, the remaining portion of the epiglottis and the hyoid bone are both impacted to the cricoid cartilage using no. 1 Vicryl sutures on a curved 65-mm needle. Three sutures are placed 1 cm apart from the midline and passed from inferior to superior submucosally around the cricoid cartilage and then to the epiglottis and hyoid in the CHEP and around the hyoid and tongue base in the CHP (Fig. 26.3A–D). Every suture begins caudally and proceeds from cricoid to epiglottis and/or hyoid. At this time, the surgeon must take care to align the hyoid with the cricoid. If the cricoid is posterior to the hyoid bone, the arytenoid cartilage will be located far from the epiglottis and/or tongue base, resulting in an increased risk for aspiration together with severe dysphonia. Also, tension-free sutures must be used to avoid the risk for postoperative rupture. The prior cervicomediastinal tracheal release is a critical part of preventing postoperative rupture of the sutures.

The deflected pyriform sinuses are repositioned lateral to the impaction to recreate the funnel shape of the hypopharyngeal inlet by restoring the lateral pharyngeal gutters. This is accomplished by placing two 3-0 Vicryl sutures in the fascia of the released inferior constrictor muscles (Fig. 26.2D). These sutures from the bilateral constrictor muscles are then tied anteriorly to its contralateral suture after the pexy is completed. The transected infrahyoid muscles are closed over the impaction by reapproximating (Vicryl 3-0) the superficial cervical aponeurosis. Suction drains are placed. The platysma muscle and finally the skin edges are carefully approximated.

POSTOPERATIVE MANAGEMENT

Airway

A cuffed tracheostomy tube is used for the first 12 hours as it provides comfort to the patient on the first postoperative night. I advocate deflating this cuff early on the first postoperative day, as it helps to restore the laryngeal closure reflex.

I consider that all of these patients have silent aspiration of saliva and occult pneumonia so postoperative broad-spectrum antibiotics are given and are continued until the tracheostomy site is closed. Antireflux therapy is also prescribed. Daily chest physiotherapy is instituted on postoperative day 1, and the patients are encouraged to ambulate.

The decision and a timetable for decannulation start by postoperative day 3. The tracheostomy tube is then plugged and is removed when the patient tolerates the tube plugged continuously during the day. If laryngoscopy demonstrates edema of the arytenoid (as is often the case with SCPLs following radiation therapy), use steroids and consider delaying the decannulation algorithm. If the patient cannot tolerate occlusion of the tracheostomy tube, frequent reassessment should be performed in order to hasten decannulation, either as an inpatient or on an outpatient basis with very close follow-up.

Swallowing

Once the patient has been decannulated, resumption of normal deglutition should follow a standardized algorithm. I advocate early removal of the tracheostomy tube prior to the feeding tube as decannulation promotes recovery of the cough reflex and thus facilitates resumption of normal swallowing. There are two issues that might significantly delay the recovery of swallowing function: (1) complete resection of an arytenoid cartilage and (2) transection or injury to the main trunk of the superior laryngeal nerve. If either happens and/or if the patient presents with the factors of advanced age >75 years, severe COPD/bronchitis, and preoperative radiation therapy, I recommend an early conversion to a percutaneous gastrostomy that will be used until resumption of swallowing without aspiration.

Prior to removal of the feeding tube, the patient should demonstrate management of their secretions with swallowing of their saliva for 3 to 5 days. Immediately after removal of the feeding tube, the patient's diet consists exclusively of a soft mechanical diet, such as pudding, Jell-O, and soft solids, which maximizes sensory feedback during swallowing. Honey, thick liquids, or carbonated beverages are gradually introduced, keeping in mind that thin liquids will be the most difficult consistency to learn to swallow. Proper positioning during swallowing is also emphasized to the patient: the head is leaned forward ("chin tuck") and the shoulders lifted. This maneuver facilitates a safe swallow by helping to tuck the neoglottis under the tongue base to improve closure and help to propel the bolus into the hypopharynx. Learning these maneuvers is greatly facilitated by a team of speech therapists, nurses, and chest physiotherapists, but the surgeon must always be involved.

COMPLICATIONS

The incidence of postoperative laryngeal stenosis that appears to be more common after CHP is noted in 3.7% of cases. If laryngeal stenosis appears later, while the initial postoperative course has been unremarkable, one must always search for submucosal local recurrence of the cancer. Obstructive sleep apnea may also present after SCPL and should be included in the surgeon's postoperative assessment, excluding laryngocele. The occurrence of postoperative laryngocele following SCPL–CHEP might be easily reduced by careful inspection of the resected specimen, ensuring that no mucosa is left behind at the level of the ventricles (transection of Morgagni ventricle).

RESULTS

In my hands, the reported oncologic results after SCPL document a 5-year actuarial local control that varies from 91.7% to 98.2% in selected T1b-3 glottic cancers. Major complications include pneumonia from aspiration, laryngeal stenosis, cervical wound infection, symptomatic laryngocele, ruptured pexis, and laryngeal chondroradionecrosis.

In the largest review to date, of 457 patients undergoing SCPLs, 58.9% of patients resumed a normal diet within 1 to 2 weeks after surgery, while transient grades 1, 2, and 3 aspiration occurred in 19%, 10.5%, and 11.6% of cases, respectively. A significant relationship was noted between aspiration and increased age and reconstruction with CHP. Also, not repositioning the pyriform sinuses or arytenoid cartilage resection was also significantly associated with aspiration. For patients who aspirate, treatment required a temporary gastrostomy, a permanent gastrostomy, and a completion total laryngectomy in 34.5%, 1.6%, and 3.7% of cases, respectively. The ruptured pexy after SCPL is a rare event noted in 0.8% of cases. The suspected cases always present with postoperative chronic aspiration; moreover, there may be palpated a gap between hyoid bone and cricoid cartilage. In the event of a ruptured pexy, the revision of SCPL is recommended. In such cases, most of the time, the anterior arch of the cricoid cartilage has been transected by the sutures. Then, the new sutures must be passed around the first two tracheal rings, the hyoid bone and the tongue base. If the epiglottis is still present (in a CHEP), transection of the median and lateral hyoepiglottic ligaments allows for release that eases closure.

PEARLS

- Postoperative speech and swallowing are made possible by the preservation of at least one cricoarytenoid unit, which includes the cricoarytenoid articulation, the superior and inferior laryngeal nerves, as well as the cricoarytenoid (posterior and lateral) muscles.
- Caution is therefore required on the uninvolved side when (1) disarticulating the cricothyroid joints (not to harm the trunk of the recurrent laryngeal nerve) and (2) transecting the aryepiglottic fold (not to harm the trunk of the superior laryngeal nerve).
- Fixation of the true vocal cord should lead to complete resection of the ipsilateral arytenoid in order to achieve complete and wide resection of the ipsilateral paraglottic space, which is key to local control.

PITFALLS

- Reconstruction should attempt to recreate a T-shaped neoglottis and not a triangular anteroposterior neoglottis. Therefore, any tissue (true vocal cord, false vocal cord) anterior to the spared cricoarytenoid unit must be resected, even if not involved by cancer.
- Early completion of a percutaneous gastrostomy is most useful in patients in whom postoperative aspiration is prone to occur (preoperative radiation therapy, age above 70, and resection of one arytenoid cartilage).

INSTRUMENTS TO HAVE AVAILABLE

- Routine tray for head and neck surgery
- The Mayo scissors and the electrocautery are used to transect the various structures.
- The Freer elevator is most valuable to disarticulate safely the cricoarytenoid joint and to deflect the pyriform sinuses.
- No. 1 Vicryl large, 65-mm reconstruction sutures on a tapered needle must be used at the time of impaction.

ACKNOWLEDGMENT

Special acknowledgment to Chris Holsinger, MD.

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27 ROBOTIC CONSERVATION SURGERY OF THE LARYNX

Gregory S. Weinstein

INTRODUCTION

The role of transoral robotic surgery (TORS) for laryngeal cancer, at the University of Pennsylvania, is essentially limited to TORS–supraglottic partial laryngectomy (SGPL). The rationale for rarely using TORS for glottic cancer is that the approaches that existed for glottis cancer prior to the introduction of TORS were effective, efficient, and safe from the functional and oncologic perspective. In general, when a new medical technology or treatment approach is introduced, adoption by clinicians requires that the new approach solves the problems with the existing therapies.

In my opinion, the standard transoral and open organ preservation surgery techniques as well as the nonsurgical approaches for glottic cancer, in selected patients, work well. At our institution, a few cases of glottic carcinoma have been operated upon using TORS. In general, this has not been found to be superior to our standard approaches. In addition, although there have been reports of robotic total laryngectomy elsewhere, these have not been yet performed at the University of Pennsylvania and therefore I am not in a position to evaluate this transoral approach in comparison to the standard open approach.

SGPL was originally described as an open procedure, which was associated with tracheostomy and a prolonged period of rehabilitation. In my opinion, although transoral laser microsurgery (TLM)–SGPL was a major improvement over open SGPL in terms of morbidity, the difficulties due to line of site exposure as well as challenges associated with surgeon's acceptance of multiple transtumoral cuts through cancer have resulted in limited adoption of this technique. In addition, the decrease in incidence of patients with supraglottic cancer who are candidates for SGPL has also contributed to fewer surgeons being trained in a technique that has a particularly long learning curve.

Given these issues, our team developed TORS–SGPL in the canine model in 2005 and in 2007 was the first to report our new procedure in humans. I have found a significant decrease in operative time and improvement in laryngeal exposure using TORS–SGPL when compared to TLM–SGPL, which I attribute to the use of the robotic technology. I have also found that the most significant benefit of TORS over TLM–SGPL is the ability to have the two hands of the assistant help the surgeon during the case. This chapter is limited to the technique of TORS–SGPL. Extended versions of the standard SGPL procedure have been described previously, and in the case of the SGPL, these would include (1) resection of the base of the tongue, (2) unilateral arytenoid resection, (3) unilateral pyriform sinus resection, and (4) unilateral or bilateral vocal cord resection. These extended procedures are not commonly performed at the University of Pennsylvania and are not included in this discussion.

HISTORY

The most common presenting symptoms in patients with supraglottic carcinoma are hoarseness, a muffled voice, otalgia, pain in the throat, or a mass in the neck. With rare exception, the more extensive lesions, which have severe obstructive symptoms such as shortness of breath, are already so large that they usually have spread to anatomic areas which preclude performing any type of SGPL.

PHYSICAL EXAMINATION

The physical examination of the primary site in the outpatient setting includes indirect or direct laryngoscopy as well as a general examination of the head and neck. Examination of the neck is important since unresectable metastasis to the neck precludes operating on the primary and bilateral extensive metastasis to the necks could result in resecting both internal jugular veins which would both also be a contraindication to TORS–SPGL.

When evaluating the larynx, the surgeon should examine the surface extent of the primary cancer and the mobility of both the vocal cords and arytenoids, as this will reflect the surface as well as the three-dimensional extent of the cancer. There are specific areas of surface extent that are important to evaluate since resection of these areas may impact on short- and long-term functional outcomes and thus impact on resectability using SGPL (see Contraindications section below).

The surfaces to evaluate include the (1) vallecula, (2) pyriform sinus, (3) mucosa of the base of the tongue, (4) arytenoid(s), (5) ventricle, (6) anterior commissure, and (7) true vocal cords. Mobility of the arytenoids and vocal cords has been correlated with depth of invasion of certain laryngeal structures.

Accurate assessment of the mobility of the vocal cords and arytenoids provides the clinician the following information: (1) a fixed vocal cord or one with impaired mobility is an indication of malignant involvement at the glottic level, (2) fixation of the arytenoid indicates lateral cricoarytenoid muscle or cricoarytenoid joint involvement, and (3) pseudofixation of the arytenoid occurs when the bulk of the tumor involves the portion of the arytenoid adjacent to the aryepiglottic fold or false cord. The clinical finding of pseudofixation of the arytenoid is seen when a cursory look from above reveals that the arytenoid is not moving but when the scope is positioned to look past the tumor at the vocal cord itself the examiner perceives mobility. Pseudofixation indicates that neither the thyroarytenoid muscle nor the cricoarytenoid joint is involved by the cancer and, barring other contraindications, does not preclude SGPL.

INDICATIONS

The T staging system provides useful standardized descriptions of malignancies, which allow the clinician to prognosticate for an individual patient or compare the potential outcomes between treatments. In the case of da Vinci transoral surgery, the Food and Drug Administration has cleared all T1 and T2 lesions. T stage indications published in the surgical literature for TORS–SGPL include selected T1, T2, and T3 cancers of the supraglottis. However, selection criteria based on the T staging system are not adequate for "en bloc" surgical triage because the T staging system divides the cancer into four categories (T1–T4), most often based on the superficial and deep extent of the cancer although sometimes not, which are too broad and general to constitute specific criteria for a particular "en bloc" operation. I emphasize the words "en bloc" here because there are treatments such as radiation therapy (whole organ treatment) or TLM (which uses piecemeal resection), in which the T staging system is used for treatment triage. In the treatments in which "en bloc" resection is not used typically, any lesion below a maximal T stage is considered "treatable," and the radiation or surgical margins are defined by the extent of the cancer, not by predefined standardized resection margins. Although there are likely as many ways to perform the precise steps of an "en bloc" surgical resection as there are qualified surgeons, there is a general consensus among practicing surgeons as to what constitutes a standardized resection for a particular "en bloc" procedure. This is true of "en bloc" procedures such as total laryngectomy, supracricoid partial laryngectomy, thyroid lobectomy, radical maxillectomy, parotidectomy, and TORS–SGPL. Simply put, specific indications for a particular "en bloc" resection occurs when the surgeon predicts that the malignancy in question, in both its' superficial and deep extent, fits within the standardized margins of resection of a particular procedure. The standardized margins of resection of TORS–SGPL include the entire epiglottis and preepiglottic space as well as both false cords.

In my opinion, the surgeon must be able to visualize in the mind's eye the three-dimensional defect of the particular operation and then, using clinical assessment in the outpatient setting, imaging studies, and intraoperative endoscopy, needs to predict that negative margins will be achieved if a particular cancer of the supraglottis is resected with the standard TORS–SGPL. Hence, although a T2 supraglottic cancer might be a candidate for TORS–SGPL, if the lesion involves the glottis, medial wall of the pyriform, or the posterior aspect of the arytenoid, it would not fit within the standardized margins of resection of the TORS–SGPL and hence the lesion would not be amenable to TORS–SGPL. On the other hand, if a T3 supraglottic cancer involved the anterior false cord and the superior petiole of the epiglottis with radiologic evidence of minimal preepiglottic space invasion, the surgeon may expect that when the standard TORS–SGPL is performed, the full extent of the cancer will fall within the three-dimensional extent of the resection and therefore it is reasonable to proceed. Since, of course, the number of combinations of both superficial and deep extent of supraglottic cancers that might be amenable to TORS–SGPL is innumerable, it would be impossible to list them all here. (This is true of specific indications for all en bloc resections, not just TORS–SGPL.)

A skeptic might argue that nonobjective selection criteria such as described herein are as much art as science and indeed are largely dependent on the knowledge and skill set of the individual surgeon. While I would in large part agree with this statement, I would counter that while nonsurgical triage may appear more objective because it is dependent on T staging, if clinicians lack anatomical knowledge of the larynx or the

clinical acumen to precisely define the superficial and deep extent of the cancer, they would likely not be able to adequately T stage the lesion. In my opinion, the very different approach to patient selection for "en bloc" surgical resection versus nonsurgical approaches such as radiation or chemoradiation is one of the major impediments to setting up a randomized trial for comparison of treatments.

CONTRAINDICATIONS

The main oncologic contraindications to the use of SGL include (1) invasion of the thyroid and/or cricoid cartilage; (2) bilateral invasion of the mucosa of the arytenoids; (3) invasion of the glottis anteriorly, posteriorly, or via the ventricle; (4) fixation of the arytenoid cartilage and true vocal cord; (5) involvement of the base of the tongue closer than 1 cm to the circumvallate papillae; (6) impaired motion of the base of the tongue; (7) invasion of the floor of the mouth in carcinoma of the vallecula; and (8) unresectable metastasis to the neck.

There are a number of nononcologic contraindications including (1) medical conditions that preclude surgery, such as severe cardiopulmonary disease; (2) mental status conditions that preclude rehabilitation; and (3) medical or pharmacologically induced coagulopathy.

PREOPERATIVE PLANNING

Imaging Studies

Radiologic studies in the assessment of head and neck cancers should be thought as complimentary to, not instead of, a clinical examination. Supraglottic cancer has a propensity to bilateral lymph node metastasis so that preoperative imaging of the neck is of particular value.

While in our experience clinical examination is superior to radiologic anatomic imaging in assessing the superficial extent of the cancer, a second area where imaging can be helpful is in evaluating specific deep cancer invasion that is not readily evaluable on clinical examination or may be helpful in confirming clinical findings. The two key areas that are best evaluated by cross-sectional imaging are malignant involvement of (1) the preepiglottic and paraglottic spaces and (2) the thyroid, cricoid, and arytenoid cartilages.

The Role of Preoperative Endoscopy

At the University of Pennsylvania, our approach is almost always to perform a triage endoscopy prior to definitive treatment. This includes patients who may have come with a prior endoscopy and biopsy. I have found it very useful to evaluate the full extent of the cancer, palpate the cancer, perform additional biopsies as indicated, and then help the patient to decide between surgical and nonsurgical treatment.

SURGICAL TECHNIQUE (VIDEO 27.1)

The Role and Timing of Neck Dissection

I recommend bilateral neck dissections. The extent of the dissection is based upon the extent of the neck metastasis. I always do the neck dissection at the same time as or prior to the resection of the primary cancer.

- *Placement of the mouth retractor*—In my opinion, the FK-WO retractor, with the longer Weinstein-O'Malley blade, is the key to providing access and exposure of the tumor for the robotic arms during TORS–SGPL. The initial view should include the epiglottis and the mucosa of the vallecula. The FK-WO retractor, with the longer right- or left-sided Weinstein-O'Malley blade, is used for most patients, while the shorter Weinstein-O'Malley blade is used for some smaller patients.

I suspend the FK-WO retractor using the chest support laryngoscope holder set upon the Mayo stand. A second point of fixation is accomplished by attaching a laryngoscope holder to the lateral aspect of the retractor frame.

- *Placement of the endoscope*—I initially use the 0-degree endoscope, but if necessary, the 30-degree endoscope can be used.
- *Placement of the instrument*—The Maryland forceps and monopolar cautery with spatula tip EndoWrists (Intuitive Surgical, Inc., Sunnyvale, CA) are used for TORS–SPGL, and I always place the electrocautery ipsilateral to the first side of the supraglottis, which is being resected.

FIGURE 27.1
The epiglottis is transected in the midline.

- *Midline transection of the epiglottis*—The epiglottis is transected in the midline down to the level of the petiole (Fig. 27.1).
- *Transection of the mucosa of the vallecula*—The mucosa of the vallecula is then transected from the midline anteriorly to approximately two-thirds of the way posteriorly. The preepiglottic space is dissected from the region of the hyoid bone and thyrohyoid membrane using the monopolar EndoWrist as a blunt dissector (Fig. 27.2).
- *Identification and dissection of the thyroid cartilage and creation of the "pocket" lateral to the paraglottic soft tissue*—Identification of the superior aspect of the thyroid cartilage is done laterally by both visualization and palpation with the tip of the monopolar cautery EndoWrist. At this point, the surgeon creates a "pocket" between the thyroid cartilage and the lateral aspect of the soft tissue of the paraglottic space down to the level of the mucosa of the lateral ventricle.
- *Transection of the false cord anteriorly*—The Maryland forceps are then used to retract the false cord posteriorly, and the electrocautery is then used to cut through the false cord. The Maryland forceps are used to pull the false cord posteriorly, and as the bottom of the false cord is reached, the mucosa of the ventricle tears from front to back. This tear is in the thin lateral portion of the mucosa of the ventricle, which is the ideal location for this mucosa to be transected.
- *Transection of the posterior margin*—The posterior resection is now completed. When the extent of the cancer allows, the goal is to preserve the (1) entire arytenoid cartilage and its overlying mucosa, (2) the inferior branch of the internal branch of the superior laryngeal nerve (SLN), the sensory nerve for the ipsilateral arytenoid and pyriform sinus, and (3) the maximal amount of the mucosa of the pyriform sinus.
- *Identification of the neurovascular bundle*—The superior laryngeal artery is identified, clipped with hemoclips and transected (Fig. 27.3). The inferior division of the internal branch of the SLN provides sensation to the ipsilateral arytenoid and pyriform sinus. Although in TORS–SGPL the individual rami of the internal branch of the SLN are not identified, the main trunk of the SLN is typically found traveling with the superior laryngeal artery laterally as it enters the paraglottic space through the thyrohyoid membrane.

FIGURE 27.2
The mucosa of the vallecula is then transected.

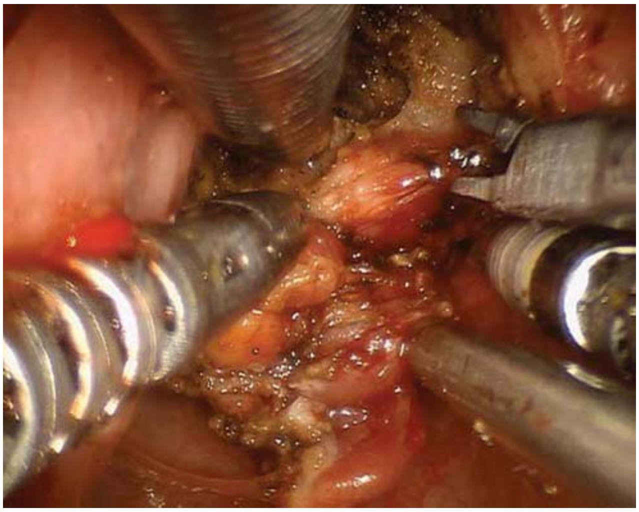

FIGURE 27.3 Hemoclip applied to the internal branch of the superior laryngeal artery.

Ultimately, the most distal branches of the SLN travel submucosally. It is best not to transect the main trunk of the SLN laterally but instead to attempt to preserve as much of the mucosa of the pyriform sinus, pharyngoepiglottic fold, and arytenoid as oncologically safe, thereby transecting the most distal portions of the SLN and preserving sensation to both the arytenoid and pyriform. This is accomplished by avoiding a soft tissue triangle bounded by the pharyngoepiglottic fold medially, the lateral aspect of the vallecula laterally, and an imaginary line, which is drawn from the point where the aryepiglottic fold reaches the most superior aspect of the arytenoid directly laterally toward the lateral aspect of the vallecula.

- *Final resection at the level of the paraglottic space and arytenoid*—The false cord is separated from its attachments on the arytenoid cartilage and posterolateral soft tissue in the area of the paraglottic space.
- *Resection of the contralateral supraglottis*—The contralateral side of the supraglottis is resected for bilateral or midline cancers (Fig. 27.4).

POSTOPERATIVE CARE

When there are concerns about edema of the airway, the patient either remains intubated or a tracheostomy is performed depending upon the judgment of the surgeon. When the patient remains intubated, this is for a period of one and a half days. A nasogastric tube is routinely placed intraoperatively.

A select group of patients includes those who undergo TORS–SGPL for radiation failure. This is an extremely rare procedure since most patients with supraglottic carcinoma who fail radiation therapy are not candidates for the procedure due to the (1) extent of the recurrent cancer, (2) condition of the radiated laryngeal tissues, or (3) other patient-related factors. However, when the rare patient with radiation failure is a candidate for TORS–SGPL (or any type of SGPL, in my experience), I recommend placement of a percutaneous gastros-

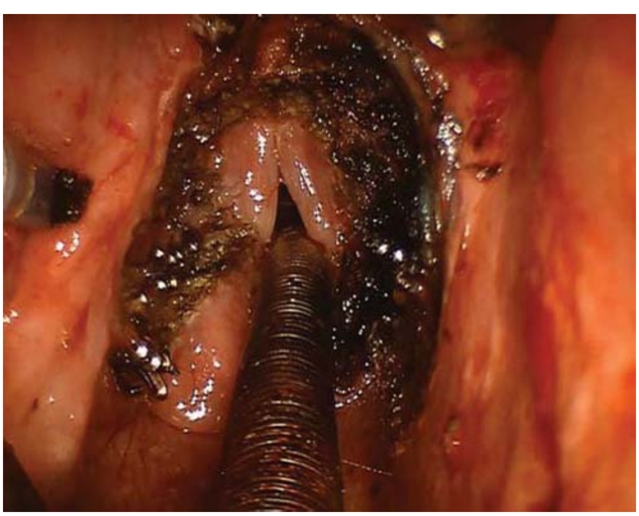

FIGURE 27.4 Wound following TORS–SGPL.

tomy since swallowing rehabilitation can take many months in these cases. If there are no complications, the patient is discharged on postoperative day 3.

The patient is seen 7 to 10 days following surgery, in the outpatient setting, at which time the surgeon evaluates the wound healing. If a tracheostomy had been previously placed, the patient should be evaluated for downsizing of the tracheostomy and decannulation based upon assessment of adequacy of the airway. The patient is also seen by a speech–language pathologist who uses clinical assessment as well as functional endoscopic evaluation of swallowing to determine the adequacy of swallowing function and timing for removal of the nasogastric tube or gastrostomy. Modified barium swallow is used only in cases of intractable swallowing problems, which are a rarity and are most often associated with (1) prior radiation, (2) damage of the laryngopharyngeal tissues secondary to adjuvant radiation therapy, or (3) in the case of no history of radiation patient-related issues (i.e., anxiety or trepidation in compliance with swallowing therapy).

In patients who require it, adjuvant radiation should not begin until the larynx is entirely healed and, ideally, full resumption of oral nutrition has resumed, to avoid long-term laryngeal dysfunction.

Once the patient is stable and has completed adjuvant treatment, routine follow-up includes every 3 months in the 1st year, every 4 months in the 2nd year, every 6 months in the 3rd and 4th year, and every 1 year between years 4 and 5. The National Cancer Network Guidelines recommend anatomic imaging only if there are symptoms. However, I concur with numerous other authors in the literature that waiting until symptoms are present to perform scans is far too late and that deep cancer invasion that is symptomatic is often incurable compared to those diagnosed earlier with scans. It is my opinion that it is medically necessary to perform anatomical imaging prior to every visit, with the exception of the 5th year. In my opinion, the literature supports the use of positron emission tomography–computed tomography in this setting.

COMPLICATIONS

Complications are rare. The key issue concerning major complications is being aware of the risks and appropriately avoiding them. Given the high temperatures achieved at the tip of the electrocautery, in any TORS where there is a risk of the tip coming into contact with an endotracheal tube there is a risk of an airway fire. Therefore, I recommend using an armored “laser” tube for all TORS–SGPL to avoid this complication.

Another rare but serious complication is bleeding. The best approach to decrease the risk of bleeding is to identify the internal branch of the superior laryngeal artery and vein and to ligate or clip the artery and the vein in all cases. If a neck dissection is done prior to the date of the primary section (or simultaneously), the superior laryngeal artery can be ligated or clipped prior to resection of the primary. From time to time, the internal branch of the superior laryngeal artery is not identified and bilaterally ligated if the vessel is small or obscure. In these cases, the surgeon should strongly consider placement of a tracheostomy to anticipate airway compromise from postoperative hemorrhage. One other point related to bleeding is the increase risk of bleeding from the lingual artery if a portion of the base of the tongue is resected with the entire epiglottis. It is my opinion that when any amount of the base of the tongue is resected, a tracheostomy should be performed. In the case of the superior laryngeal artery and in the latter case with two vessels at risk of bleeding, since there is no epiglottis for airway protection in the face of even a moderate hemorrhage, a tracheostomy will provide crucial time for the surgeon to avoid airway compromise and to bring the patient back to the operating room to explore the wound and to cauterize or clip the appropriate vessels.

Airway compromise is an increased risk in the patient with a small larynx as well as in the morbidly obese patient, those with severe sleep apnea, and patients with prior radiation of the head and neck (where edema is the norm). The surgeon should strongly consider placement of a tracheostomy at the time of primary resection in all of these situations. Pneumonia, while rare, can occur.

RESULTS

The reports to date in the literature indicate that TORS–SGPL is safe from both the oncologic and functional perspective. Following the publications in 2007 by Weinstein et al., first description of TORS–SGPL in humans, numerous centers have published retrospective series. Olsen et al. in 2012 reported on nine patients undergoing TORS–SGPL and concluded that it was a promising approach, and they found in particular that en bloc resection could be performed more often and that TORS decreased operative time compared to other transoral techniques. The series from Ohio State University was published by Ozer et al. in 2012, and they also found shorter operative times with an average operative time among their 13 patients to be 25.3 minutes. Ozer et al. also had excellent oncologic and functional outcomes with negative margins in all cases and no patients requiring a permanent tracheostomy or gastrostomy tube. Mendelsohn et al. reported on 18 patients undergoing TORS–SGPL at Louvain University Hospital in Belgium with no patients undergoing either tracheostomy or gastrostomy tube. The Belgium group also reported on excellent 2-year oncologic outcomes of 83% local regional control and 100% disease-specific survival. Park et al. from Yonsei University College of Medicine in Seoul, Korea, published their results of 16 patients undergoing TORS–SGPL in an effort to validate the

technique and found a 91% 2-year Kaplan-Meier disease–free survival with only 1 of 16 patients having had recurrence, which presented as lung metastasis. In addition, the Korean series had no patients who required long-term gastrostomy or tracheostomy.

PEARLS

- TORS–SGPL is an excellent alternative for selected T1, T2, and T3 cancers of the supraglottis.
- The FK-WO retractor system (Olympus, Inc.) using the Weinstein-O'Malley blade was designed specifically for TORS–SGPL, and I have found it to be very useful for exposure of the larynx.
- The wristed action of the robotic EndoWrists is useful for creating a "pocket" between the thyroid cartilage and the lateral aspect of the paraglottic space.
- Rather than cutting the mucosa of the ventricle, posterior retraction of the false cord, as it is transected anteriorly, neatly tears the mucosa of the ventricle in its thinnest portion, again being a distinct advantage of wristed instrumentation.
- When the extent of the cancer allows, the surgeon should attempt to spare the inferior division of the internal branch of the SLN, which may preserve mucosal sensation and aid in swallowing rehabilitation.

PITFALLS

- A separate triage endoscopy is important to evaluate the patient.
- Lack of adequate exposure may make it impossible to perform TORS–SGPL.
- Lack of applying hemoclips to the internal branch of the superior laryngeal artery may lead to postoperative bleeding. Some surgeons advocate bilateral ligation of the superior laryngeal artery prior to robotic surgery during the completion of bilateral neck dissections.
- Tracheostomy should be considered by the surgeon when risk factors for airway compromise are present.
- The chance of an airway fire during TORS–SGPL can be diminished by using an armored endotracheal tube.

INSTRUMENTS TO HAVE AVAILABLE

- FK-WO retractor system (Olympus, Inc.)
- Maryland 5-mm EndoWrist (Intuitive Surgical, Inc.)
- Spatula cautery 5-mm EndoWrist (Intuitive Surgical, Inc.)

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28 NEAR-TOTAL LARYNGECTOMY

Pankaj Chaturvedi

INTRODUCTION

The management of locally advanced stage 3 and 4a cancer of the larynx and hypopharynx usually requires multidisciplinary treatment. Most head and neck surgeons would probably suggest total laryngectomy (TL) with adjuvant radiotherapy, whereas most oncologists would choose a nonsurgical treatment such as a combination of chemotherapy and radiotherapy. The choice between the two modalities is dependent upon patient factors and cancer factors. The cancer-related factors are mainly clinicoradiologic parameters such as gross cartilage invasion or deep invasion of the base of the tongue. The most important factor for any treatment protocol is a patient who is fit and gives his/her permission.

The aim of treatment should always be organ preservation or at least voice preservation if possible. In patients undergoing TL, tracheoesophageal puncture (TEP) and insertion of a voice prosthesis is the most commonly used procedure for restoration of voice. TEP is a time-tested, simple, and effective technique that results in good quality of voice in laryngectomy patients. However, TEP has a few significant limitations mainly related to maintenance, malfunction, replacement, and recurring cost. Some of the common problems are need for a regular cleaning, intraprosthesis leakage, periprosthesis leakage, overgrowth of granulation tissue, frequent replacement, spontaneous extrusion, and spastic pharyngoesophageal segment. These problems may lead to discontinuation in more than two-thirds of patients particularly after the 2nd year.

Near-total laryngectomy (NTL) is an alternative to TL in selected patients with advanced cancer of the larynx and pyriform sinus. NTL is an oncologically safe procedure and offers the advantage of a maintenance-free biologic prosthesis that obviates the need for an artificial device with its associated problems. This procedure is oncologically sound and preserves voice (not the organ), but the patient is left with a permanent tracheostoma and permanent loss of nasal breathing. The procedure was first described by Pearson et al. in 1980 under the name of "extended hemilaryngectomy." This surgery has also been called a subtotal laryngectomy. NTL is perhaps the most accepted terminology for this procedure. This surgery exploits the phonatory ability of an innervated cricoarytenoid unit.

HISTORY

NTL is a surgical procedure for selected cases of locally advanced cancer of the larynx and pyriform sinus. These patients usually present with a change in the voice, pain, foreign body sensation in the throat, otalgia, dysphagia, odynophagia, breathlessness, and a mass in the neck. Patients with glottic cancer usually present at an earlier stage due to the early onset of hoarseness. Due to the paucity of lymphatic channels in the vocal cord and early detection, metastases to the cervical lymph nodes are uncommon. Cancers of the pyriform sinus and supraglottic region present in more advanced stages because of lack of symptoms in the early stage of the disease.

These regions are rich in lymphatics; therefore, metastases to the cervical lymph nodes are a common feature. Cancers of the larynx and pyriform sinus may present with shortness of breath due to either vocal cord paralysis or mass effect that may lead to obstruction of the laryngeal inlet by the sheer bulk of the cancer. Progressive dysphagia is a sign of circumferential pharyngeal involvement usually in a case of cancer of the hypopharynx. Otalgia denotes a deeply infiltrative lesion that leads to a referred pain in the ear. Aspiration of liquids is associated with vocal cord paralysis and failure of closure of the laryngeal inlet while drinking or eating. The etiology of all these cancers is usually tobacco, alcohol, and human papillomavirus or a combination of these factors.

PHYSICAL EXAMINATION

Complete examination of the head and neck including indirect or direct laryngoscopy should be performed in all patients. Most patients require a fiberoptic examination that helps in precise tumor mapping, pictorial documentation and biopsy. Since fiberoptic examination may not be adequate in the assessment of the hypopharynx, I prefer direct rigid laryngoscopy under anesthesia. This allows me to rule out second primaries, map the lesion better and obtain an adequate biopsy. Stroboscopy is a useful procedure in evaluating early cancers of the vocal cord, which may be amenable to microlaser surgery.

A careful examination of the oral cavity and oropharynx is necessary to rule out the presence of a second primary cancer. The important things that one has to look for during indirect laryngoscopic examination are extent of disease, adequacy of the laryngeal inlet, and mobility of the vocal cords. The neck should be palpated bilaterally to detect the presence of cervical lymph node metastases. The level of the lymph nodes, number, size, mobility, and fixation to the skin or deep structures are important clinical features. Careful mapping of the cancer specifically focusing on the interarytenoid, retroarytenoid, and postcricoid regions as well as the status of the contralateral vocal cord is necessary in the planning of NTL.

INDICATIONS

- Cancer of the larynx—NTL suitable for lateralized laryngeal cancers, mainly T3 or T4 cancers. It can also be used in transglottic cancer.
- Cancer of the pyriform sinus—NTL is suitable for T3 and T4 lateralized cancer of the pyriform sinus.
- The lesion that is suitable for partial laryngeal surgery, but the patient is not suitable for the surgery due to old age or poor pulmonary function, may be considered for NTL.

CONTRAINDICATIONS

- Involvement of the interarytenoid or postcricoid regions
- More than one-third involvement of the contralateral cord.
- Fixation of both vocal cords.

PEROPERATIVE EVALUATION

Clinical examination alone is less accurate in assessment of cartilage erosion or extralaryngeal spread, lymph node metastases, and soft tissue invasion. Computed tomography (CT) scan is one of the most trusted imaging studies used in the evaluation of cancers of the larynx and pharynx. CT scan detects cartilage erosion or invasion, soft tissue infiltration, metastases to the lymph nodes, and invasion of important organs with reasonable accuracy. Magnetic resonance imaging is more sensitive but is less specific than CT scan in detecting cartilage erosion. The role of preoperative positron emission tomography scan is not very well defined in these cancers. A biopsy confirmation is mandatory before embarking on surgery.

NTL is not an organ-preserving surgery but a voice-preserving surgery. The prerequisites for the organ-preserving surgeries or partial laryngectomy procedures are an intact cricoid ring and at least one functional innervated cricoarytenoid unit. NTL is still feasible in cases where the entire cricoid ring cannot be preserved. This surgery is as radical as the TL while preserving an innervated cricoarytenoid unit for speech similar to the mechanism for a supracricoid laryngectomy. In NTL, a radical removal of the cancer along with the involved cricoid ring is performed on the predominant side. On the opposite side, the recurrent laryngeal nerve (RLN), the arytenoid, adjoining cricoid (forming the cricoarytenoid unit), and a 1 to 1.5 cm strip of the posterior wall of the trachea are preserved. This laryngotracheal remnant is sewn to create a tube to form an innervated myomucosal shunt that diverts air from the trachea to the pharynx and produces voice. Though these patients do not have nasal breathing, they are able to produce voice by occlusion of the stoma by the finger.

SURGICAL TECHNIQUE

Incision

- Gluck Sorenson's incision ("U"-shaped incision) is normally used similar to TL.
- Raise subplatysmal flap up to a level above the hyoid bone.

Neck Dissection

- An appropriate neck dissection always precedes the removal of the primary tumor. For a clinically positive neck, the neck dissection removing levels II–V is advocated. For a clinically negative neck, the neck dissection removing levels II–IV is a widely accepted strategy.

Skeletonization of the Larynx

- Following neck dissection, the sternocleidomastoid muscles are mobilized bilaterally. Separate the internal jugular vein and carotid artery from midline structures on both sides.
- The omohyoid muscles and other strap muscles (sternohyoid and sternothyroid) are divided at their origin in the inferior aspect of the neck thereby exposing the thyroid gland and the trachea.
- The ipsilateral thyroid lobe is sacrificed in most of the cases. The ipsilateral superior/inferior thyroid vessels and middle thyroid vein are divided. The RLN ipsilateral to the cancer is sacrificed. The entire thyroid lobe is dissected out to expose the underlying trachea, cricoid, and thyroid cartilages.
- The thyroid cartilage, on the uninvolved side, is divided with a heavy Mayo scissors 5 mm from the lateral border. Care should be taken to avoid entry into the larynx at this point. This step is done to facilitate further steps of the procedure.
- The entire hyoid bone is skeletonized by severing the suprahyoid muscles along the superior border of body and greater cornu of the hyoid hugging the bone so as not to damage the hypoglossal nerve and lingual artery. The hypoglossal nerve lies superficial to the muscle and lingual artery lies deep to the muscle.

Tracheostomy

- A tracheostoma is created through the third or fourth tracheal ring

Dissection on the Contralateral Side

- Care must be taken to preserve the RLN on the uninvolved side. This is mandatory for function of the myomucosal shunt.
- The contralateral thyroid lobe along with its blood supply is reflected laterally after dividing the isthmus to expose the underlying thyroid, cricoid, and tracheal cartilages.
- To prevent any injury of the contralateral RLN, any dissection in the region of the cricothyroid joint should be avoided. This is the point where RLN enters to innervate the arytenoid muscles.
- A part of the posterior border of the thyroid cartilage along with the cricothyroid joint should be left intact so as to preserve the RLN.

Laryngeal Entry

- After exposing the superior border of the hyoid bone and exposing the mucosa of both valleculae, a transvallecular entry is made (Fig. 28.1).
- The epiglottis is held and pulled anteriorly and inferiorly to inspect the entire cancer.
- Look for the interarytenoid region and assess if one arytenoid can be saved without compromising the surgical margin.

Laryngeal Dissection

- The incisions are extended along both sides of the epiglottis (Fig. 28.2).
- On the involved side, the mucosal and soft tissue incisions are made with an adequate margin around the cancer.
- On the contralateral side, incisions are made along the border of the epiglottis, supraglottis, and false cord until the anterior commissure is reached. At this point the vocal cords are detached from the anterior commissure. The incisions that were started from the border of the epiglottis to the supraglottis are extended until the cricoid cartilage is identified.
- The interarytenoid mucosa is divided maintaining good surgical margin and avoiding denuding the arytenoid cartilage.

FIGURE 28.1
Showing incision for entry through the vallecula and the lateral pharyngeal wall after cutting through the thyroid cartilage.

- This mucosal excision is extended to divide the soft tissue and cricoid cartilage.
- The entire specimen is pulled superiorly and anteriorly to expose the inferior border of the cricoid cartilage. A horizontal incision is made along the inferior border of the cricoid cartilage so as to join the other mucosal incisions.

Construction of the Myomucosal Shunt

- Excess cricoid cartilage prevents proper formation of the mucosal tube shunt; therefore, submucosal dissection with removal of the excess cricoid cartilage is done, sparing the segment of the cartilage on which the arytenoid cartilage rests (Fig. 28.3).
- If the remnant of laryngeal mucosa is inadequate to form a shunt, it may be supplemented by rotation of the uninvolved mucosa of the pyriform sinus.

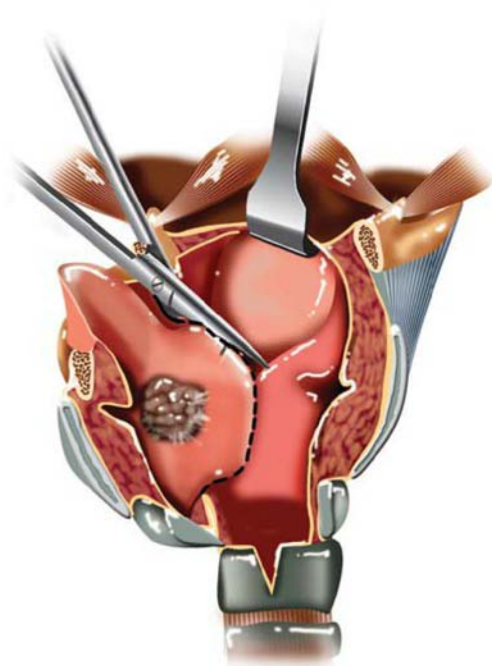

FIGURE 28.2
Showing mucosal incision through interarytenoid region, inferior border of cricoid cartilage (on the cancer side), and the pyriform sinus.

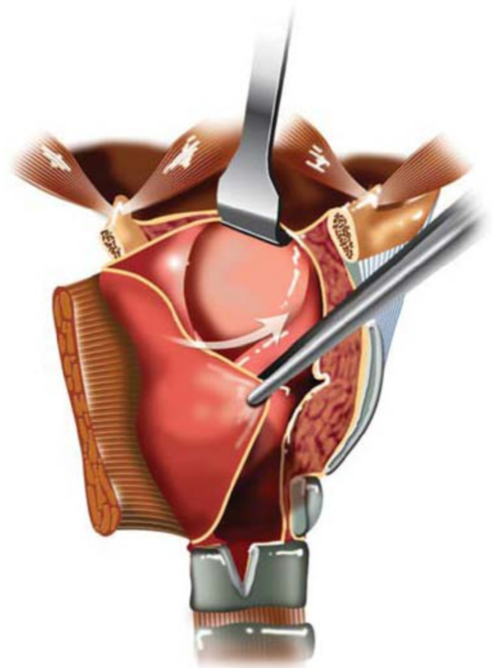

FIGURE 28.3 Rotation of remnant contralateral vocal cord to form the myomucosal shunt.

- The myomucosal shunt is now created from the remaining tissue of the contralateral hemilarynx. The shunt tube formation is started from the tracheal end and progresses superiorly. The free edges of the mucosa may need to be detached from the underlying cartilage to facilitate forming the tube.
- To ensure an adequate diameter of the shunt for phonation, I prefer to place a 14-French Foley catheter or a rubber catheter of equivalent diameter while forming the tube.
- A "V"-shaped excision of the upper two tracheal rings may facilitate formation of the shunt that resembles an inverted funnel that opens into the tracheostoma.

Pharyngeal Closure

- A nasogastric tube is inserted prior to closing the pharynx.
- After formation of the shunt, the hypopharyngeal mucosa is closed to form the neopharynx (Fig. 28.4).
- The pharyngeal end of the shunt is carefully invaginated into the neopharynx.

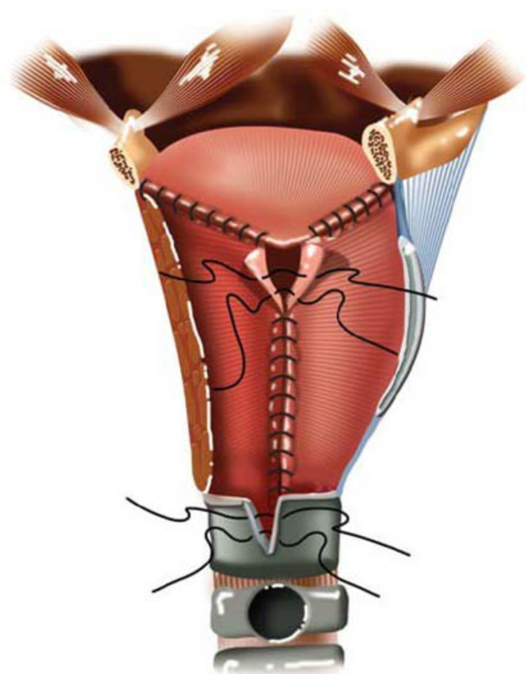

FIGURE 28.4 T-shaped closure of neopharynx.

- If the remaining mucosa is inadequate for formation of a functioning neopharynx, patch pharyngoplasty should be done using a pectoralis major myocutaneous (PMMC) flap.
- It is better to remove a disc of skin for making a permanent tracheostoma. This prevents stomal stenosis in future.

POSTOPERATIVE CARE

- There is no need to place a tracheostomy tube.
- Nasogastric tube feeding is started from the 1st postoperative day, and if there are no signs of any salivary leak, oral feeding may be started from the 7th postoperative day and the NG tube removed.
- Though there is controversy regarding when to initiate attempts to speak, I advise my patients to start after the 2nd postoperative week.

ADJUVANT TREATMENT

Patients with adverse prognostic factors, such as cartilage invasion, perineural invasion, or metastases of the cervical lymph nodes, require adjuvant radiotherapy with or without concurrent chemotherapy. Postoperative radiotherapy does not prevent the subsequent development of speech or deglutition.

COMPLICATIONS

The overall incidence of postoperative complications after NTL varies from 28.9% to 80%. The most common complications among them are pharyngeal fistula, aspiration, and stenosis of the shunt.

Pharyngeal Fistula

Almost all studies suggest that a pharyngeal fistula is the most common complication of NTL. The incidence varies between 4.6% and 53%. This incidence is higher than that following TL. This may be attributed to the increased tension over the suture line in case of NTL due to closure of the pharynx over the voice shunt. The incidence of pharyngeal leak may be minimized by the judicious use of a PMMC flap to close the pharyngeal defect.

Shunt Aspiration

In case of a large shunt, fluid may leak into the lungs through the tracheostoma. The incidence of minor aspiration that does not require any intervention is up to 33.3%, whereas the incidence of major aspiration requiring interventions ranges from 0% to 9%. In case of major aspiration requiring surgical correction, a fiberoptic examination is advised to see whether the shunt is dynamic or not by observing the fluttering of the shunt orifice. In severe cases, if the shunt cannot be narrowed or made functional, complete closure of shunt is advised.

Shunt Stenosis

It is the most common cause of inability to speak following NTL. The incidence of shunt stenosis is up to 15% in large series. The problem can be avoided during the surgery by achieving adequate shunt size (0.6 cm). In case of lack of adequate tissue, adjacent pyriform mucosa can be used to augment the shunt. Most shunt stenosis can be managed by dilatation in the outpatient clinic under topical anesthesia. A thin malleable probe is introduced from the stomal end of the shunt upward without undue pressure. In some patients, a single dilatation may be sufficient, but in others, multiple dilatations may be required to effectively dilate the shunt.

RESULTS

Oncologic Outcomes

Following NTL, patients with cancer of the larynx have a better overall survival than those with cancer of the pyriform sinus. Among laryngeal cancer, those with subglottic extension have the worst outcome. Among pyriform sinus cancers, lesions involving the medial wall have a better outcome than those involving the lateral wall. According to different studies, the 5-year overall survival varies between 48% and 82%. The incidence of local recurrence following NTL varies between 3% and 20%. Pearson et al. suggested that 5-year local control after NTL is similar to that expected with TL.

Speech

The main aim of NTL is complete clearance of the cancer with preservation of voice without using any voice prosthesis. Studies with significant numbers of patients suggest that the incidence of production of good intelligible speech after NTL is between 74% and 90%. A study from our institute suggests that though some patients can phonate as early as the 2nd postoperative week, the majority starts speaking only after completion of postoperative radiotherapy and settling of acute reactions and edema. When the voice quality of NTL is compared with the voice quality of TEP, it has been observed that the fundamental frequency, frequency range, and maximum frequency are better in NTL group than the TEP group. This suggests that the phonation with a biologic shunt is better than that with the prosthetic shunt. Another study suggests that there is no significant difference between voice function following NTL and vertical horizontal laryngectomy.

PEARLS

- As NTL can be performed only in a selected group of patients, a detailed radiologic and direct laryngoscopic evaluation is mandatory.
- Educating the patients regarding postoperative outcomes especially regarding shunt speech and the presence of permanent tracheotomy is critical.
- Oncologically the procedure is as safe as TL if the patients are selected judiciously.
- Care should be taken to preserve the contralateral RLN and arytenoid during the surgery.
- During surgery it is better to stent the shunt with 14-French Foley catheter or red rubber catheter no. 6, to maintain at least 6 mm diameter of the shunt for phonation without straining.
- To decrease the incidence of pharyngeal fistula, PMMC flap should be used to form the neopharynx whenever required especially in selected cases.

PITFALLS

- NTL should only be done in a highly selected group of patients.
- NTL cannot be considered a conservation laryngeal surgery as patients live with a permanent tracheotomy.
- High expertise and surgical skill is required for the procedure.

INSTRUMENTS TO HAVE AVAILABLE

- All routine instruments of head and neck surgery
- 14-Fr Foley catheter or a rubber catheter of equivalent diameter
- Heavy Mayo scissors

ACKNOWLEDGMENT

I would like to sincerely thank Dr. Sourav Datta, Research Fellow, for helping me complete this chapter.

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29 TOTAL LARYNGECTOMY

Gregory T. Wolf

INTRODUCTION

Total laryngectomy is one of the most life-altering surgical procedures that a head and neck surgeon performs. The resulting alterations in speech, swallowing, and quality of life are viewed by patient and physician as challenges so significant that alternative treatment approaches that attempt to preserve the function of the larynx, such as radiation therapy, combined chemoradiation, and organ-preserving extended conservation resections, are often adopted even though overall cure rates may not be as good as with total laryngectomy. Despite this, patients with advanced cancer of the larynx have some of the best overall survival rates compared to other sites of cancer of the head and neck. These rates are likely related to anatomic characteristics that affect patterns of spread and allow complete extirpation. The increasing use of organ preservation treatment approaches has relegated total laryngectomy to a strategy for secondary salvage of local cancer recurrences, which has been blamed for the decline in overall cure rates for patients with laryngeal cancer over the past two decades.

Secondary total laryngectomy after a failure of prior organ-preserving therapy is now one of the most common and most difficult procedures performed by the head and neck surgeon. The principles guiding successful surgery have not changed, but the complexities of cancer surveillance after sequential treatments, decision making, precise determination of extent of the cancer, and related tissue factors must be carefully considered in planning for a total laryngectomy. Although this chapter is devoted to describing a surgical technique that has been in use for more than a century, nuances that reflect changes in modern treatment and rehabilitation approaches are emphasized.

Advanced cancer of the larynx remains one of the most favorable types of head and neck cancer for long-term cure. The mainstay of treatment, and the standard to which all other treatment modalities are compared, is complete surgical resection. Adjuvant postoperative radiation is routinely added in many cases resulting in modest increases in survival rates. However, functional sequelae associated with a radical surgical resection that requires a total laryngectomy include permanent alterations in speech, swallowing, and respiration, which negatively impact quality of life. Because of these problems, alternatives to radical surgical excision have been popularized in an attempt to avoid permanent tracheostoma and loss of natural voice and now represent the most common standard treatment approach.

Over the last 15 to 20 years, the initial management of these patients has been changing with the development and increasing use of organ-preserving treatments such as advanced function-preserving partial laryngectomy procedures, chemotherapy and radiation protocols (induction and concurrent), and radiation therapy alone for patients who previously might have been considered for total laryngectomy. In every instance, except for neoadjuvant chemotherapy combined with radiation, direct randomized comparisons to radical surgical resection have not been performed.

Clearly, no single treatment approach is suitable for all advanced-stage laryngeal cancer patients. The key to a successful outcome is optimal patient selection. Proper selection is enhanced by using the varied expertise of a multidisciplinary treatment team that involves experts in head and neck surgery, radiation oncology, medical oncology, pathology, radiology, speech and swallowing experts, audiology, social services, and nutritionists.

At the University of Michigan, I have successfully pioneered treatment concepts based on selecting definitive management (radiation vs. total laryngectomy) based on the biologic (clinical) response of the primary cancer to a single cycle of induction chemotherapy. This individualized approach accepts the rationale that responding cancers are most often cured with definitive radiation, while nonresponding cancers are rarely controlled long term after radiation therapy. Surgical management is enhanced by permitting total laryngectomy to be performed prior to radiation therapy in most cases, and survival rates for these patients are exceptional.

In nearly every prior report of neoadjuvant chemotherapy, clinical complete tumor regressions are associated with improved survival compared to nonresponders. This principal was the basis for the landmark Veterans Affairs laryngeal cancer study, as patients with poor response to induction chemotherapy were treated with total laryngectomy followed by radiotherapy. I have taken these observations and tested the concept in a series of proof of principle phase II trials combined with correlative biomarker studies. In doing so, I have demonstrated, in advanced stage III and IV patients, overall 5-year survival rates in excess of 80% with laryngeal preservation in 70% of patients. Chemotherapy response appears consistently associated with aggressive tumor markers, high tumor proliferation rates, and histologically invasive growth patterns. I have achieved these long-term results without excluding patients on the basis of tumor factors such as tumor size or cartilage invasion but only selected them on the basis of their ability to tolerate chemotherapy and radiation. Despite these new treatment approaches, total laryngectomy remains an important initial therapeutic option for select patients (Table 29.1) as well as a means of secondary surgical treatment when more conservative treatment fails.

HISTORY

Typically patients with primary cancer of the glottis even of early stage present with hoarseness hopefully leading to earlier diagnosis and treatment. Symptoms of more advanced cancers may include referred otalgia, odynophagia, dysphagia, hemoptysis, or cervical lymph adenopathy. Stridor and airway compromise generally occur later when the cancer is large or bulky and obstructs the airway.

Patient evaluation should include a detailed assessment of speech and swallowing function, communication needs, nutrition, health behaviors, age, comorbidities, and availability of social support for what is typically a prolonged period of treatment and rehabilitation. Critical factors in a patient's history include those symptoms related to respiration and swallowing (particularly aspiration) that indicate impaired function. The greater the severity of symptoms, the more likely the patient will be a candidate for and benefit from total laryngectomy. Organ preservation treatment strategies using combined chemotherapy and radiation do not generally improve the speech or swallowing functions when large amounts of laryngeal tissue and framework (T4) are destroyed by the cancer since these structures are replaced with scar tissue after cancer regression. Likewise, long-term swallowing function can also be affected by fibrosis of the pharyngeal muscles and stricture formation.

Primary cancer of the supraglottis can be advanced stage at presentation since hoarseness is a late finding and cancers can be quite large without much symptomatology. Early symptoms include chronic sore throat, dysphagia, referred otalgia, or a mass in the neck. Even a small primary cancer of the supraglottis can metastasize early in the course of the disease. Age and comorbidities are important since a decision for nonsurgical organ preservation may depend upon receiving chemotherapy and elderly patients generally do not benefit from adjuvant chemotherapy. Comorbidities may limit a patient's ability to tolerate the toxicity associated with chemotherapy. Likewise, severe comorbidities might increase anticipated surgical complications or even contraindicate total laryngectomy. The length of time the symptomatology has been present is important since it can indirectly relate to the rate of growth of the cancer. Anyone with persistent hoarseness (>6 weeks) or sore throat (>6 weeks) warrants a thorough endoscopic examination of all the mucosal surfaces within the upper aerodigestive tract, especially in those patients with a heavy smoking history or a strong family history of cancer. Since most laryngectomies are now performed following a failure of prior chemoradiation, careful review of records of drug administration, toxicities, and radiation doses and fields is helpful in planning surgery, optimizing preoperative medical status, and anticipating reconstructive needs such as replacement of the skin, free flap reconstruction, or dermal graft coverage of the great vessels. Likewise, prior information regarding initial cancer staging prior to chemoradiation should be carefully evaluated to assist in planning adequate resection of the cancer since it is still standard technique to remove all tissue at risk of harboring residual neoplasm.

The patient's history of airway symptoms and direct visualization of the larynx will guide eventual strategy and planning for general anesthesia and tracheal intubation. This plan should be documented and discussed with the anesthesiologist preoperatively. Clear communication and decision-making issues related to obstructing cancers, distorted anatomy, anesthetic technique, and awake fiberoptic intubation versus tracheostomy are needed to avoid unnecessary patient risk. Factors such as fibrosis of the neck and trismus are equally important and can interfere with oral intubation even if an obstructing tumor is not present. After securing the airway, tumor debridement at the time of staging endoscopy and biopsy can often avoid the need for tracheostomy prior to total laryngectomy. Difficulties encountered with airway management before or after diagnostic endoscopy should be documented and may influence techniques selected for anesthesia induction at time of total laryngectomy. Preoperative thyroid function testing should be considered if prior radiation to the neck has been delivered since iatrogenic hypothyroidism can affect wound healing. Nutritional status and plans for postoperative nutritional replacement should be considered.

PHYSICAL EXAMINATION

An important principle is that no physical examination should be considered complete until all mucosal surfaces of the nasal cavity, nasopharynx, oropharynx, oral cavity, hypopharynx, and larynx have been clearly visualized. Second primary cancers have been reported in up to 20% of patients who have laryngeal cancer making a thorough examination of other sites mandatory. The examination of the head and neck must also include a detailed examination of the regional lymphatics, including palpation of the thyroid and prelaryngeal and pretracheal anatomy.

Visualization of the larynx can be performed indirectly with a handheld mirror or directly with fiberoptic laryngoscopy. Fiberoptic examination has the advantage of providing a more detailed look at the laryngeal anatomy and is probably more accurate for in-office cancer staging. Functional evaluation assessing vocal cord mobility, voice characteristics, and swallowing are facilitated by fiberoptic endoscopy. The gold standard, however, for precise tumor evaluation and staging is to combine functional evaluation with direct laryngoscopy under general anesthesia in the operating room. With large, obstructive cancers, a tracheostomy under local anesthesia in the awake patient or fiberoptic-assisted awake intubation may be necessary to safely induce general anesthesia and perform a direct laryngoscopy. In patients with large cancers where endotracheal intubation is possible, debulking the cancer may provide a sufficient airway to obviate the need for a tracheostomy, thus decreasing the potential risk of seeding of the cancer at a tracheostomy site. Despite operative direct laryngoscopy, the extent of cancer is underestimated in 30% to 40% of glottic and supraglottic cancers and close to 50% of transglottic cancers. Depth of invasion and cartilage involvement are the most difficult variables to estimate clinically. Subglottic cancer is particularly difficult to evaluate and the extent of cancer involvement is also frequently underestimated. The use of rigid telescopes (0 and 30 degrees) during direct laryngoscopy provides the best clinical evaluation of the subglottis.

INDICATIONS

Indications for total laryngectomy include both cancer-related factors and functional factors and are summarized in (Table 29.1). Failure of primary radiation therapy remains the most frequent indication for total laryngectomy. Failures of radiation for small (T1, T2) glottic primaries can often be managed with conservation laryngectomy techniques (endoscopic or transcervical), while supraglottic failures usually require a total laryngectomy because of wound healing problems or poor results with extended or supracricoid laryngectomy techniques. Advanced cancers with extensive destruction of the laryngeal cartilage usually result in a nonfunctional larynx after chemoradiation and such patients would benefit from primary laryngectomy. Primary cancers of the subglottis often require total laryngectomy because of invasion of the cricoid cartilage. Primary chondrosarcomas of the laryngeal framework sometimes require total laryngectomy and even invasive cancer of the thyroid or extensive cancers of the base of the tongue may require incidental total laryngectomy. Sometimes, a patient's pulmonary or medical status may make conservation laryngectomy risky and total laryngectomy or other organ preservation approach preferable. The usual indications include:

TABLE 29.1
• Patients with advanced (stage III/IV) cancer of the glottis, supraglottis, or subglottis • Patients with advanced (stage II/III/IV) cancer of the hypopharynx • Secondary treatment after failed organ preservation treatment • Selected patients with early (stage I/II) cancers that have progressed after prior conservation surgery or radiation • Nonfunctional larynx after prior nonsurgical treatment • Chondroradionecrosis • Intractable aspiration

CONTRAINDICATIONS

If the extent of the cancer and the patient's medical condition allow for complete resection and safe general anesthesia, there are few contraindications to total laryngectomy. The presence of distant metastases is probably the most common contraindication since it makes little sense to do a total laryngectomy without the opportunity for cure since the median life expectancy with distant metastasis is <6 months. Extension of cancer to the deep neck and adjacent critical structures is a relative contraindication. Total laryngectomy is unlikely to be curative if the cancer encases a carotid artery or has direct involvement of the deep neck muscles, mediastinal structures, cervical vertebrae, or prevertebral fascia. The presence of extensive supraclavicular lymph node

metastases, dermal metastases, or direct involvement of the skin is usually a sign of disseminated disease and relative contraindications, and alternative palliative treatment with chemoradiation might be recommended. If the primary cancer obstructs the airway or interferes with swallowing, patients can function reasonably well with a tracheostomy and an enteral feeding tube for long periods even if distant metastases are not apparent.

PREOPERATIVE PLANNING

Radiologic imaging is a natural complement to a complete history and examination of the head and neck. Failures after radiation therapy are typically more extensive than the gross surface representation of the cancer, and clinical assessment alone is unreliable and typically underestimates the extent of microscopic cancer. Magnetic resonance imaging (MRI) and computerized tomography (CT) both offer detailed evaluation of laryngeal anatomy that can reveal preepiglottic and paraglottic space involvement as well as submucosal and extralaryngeal extension and involved regional lymph nodes that may not be obvious on clinical examination. A high-resolution thin section CT scan is generally preferred since breath holding is necessary for MRI imaging and motion artifact can obscure many of the finer imaging details. Invasion of the thyroid cartilage (T4) and extralaryngeal spread of cancer have been proposed as contraindications for organ preservation protocols; however, successful nonsurgical management of T4 larynx cancer and those with minimal cartilage invasion has been reported. Invasion of the thyroid cartilage can be evaluated with imaging and is probably better assessed with CT rather than with MRI although each has significant limitations and direct evaluation at endoscopy is critical. The introduction of positron emission tomography (PET) scanning and combined CT registration with PET imaging has opened a new frontier for functional imaging. These newer imaging studies can detect occult disease in up to 20% of patients, although sensitivity is generally regarded as low and PET is perhaps most useful in assessing the possibility of distant metastasis and second primary cancers. Preoperative imaging of the chest is important and this is probably best accomplished with chest CT rather than a standard chest radiograph.

The patient's history and physical examination must support the decision to perform a total laryngectomy. Important considerations include the growth rate of the cancer, which is often reflected by the length of patient symptoms in previously untreated patients or the interval since last treatment for patients with recurrent cancer. Tissue confirmation of malignancy is necessary and is obtained at the time of staging endoscopy under anesthesia. Mutilating, radical surgery should never be done on the basis of a frozen section diagnosis unless there is absolute certainty of malignancy. This, combined with functional evaluation in the awake patient, is important to determine the depth of invasion and whether barriers to microscopic spread (Table 29.2) have been violated. These considerations should be documented since they will influence planned extirpation margins, location of entry into the airway and reconstruction. Tissue biopsy also allows assessment of the microscopic pattern of invasion, perineural/vascular invasion, and acquisition of tissue for assessing immunohistologic molecular markers such as p53, EGFR, p16, PCNA, and Bcl2/Bcl-xL expression that could be useful in the future analysis of treatment results. Rapidly growing cancers and those with aggressive growth patterns or with biologic markers such as high PCNA, p53 mutation or low Bcl-xL expression may be better treated with radiation and chemotherapy rather than surgery. Preoperative assessment and counseling for speech, swallowing, and nutrition should be considered in all patients and anticipated social support and home care needs anticipated.

Preoperative planning must include detailed assessment of the regional lymphatics including palpation of the thyroid and prelaryngeal and pretracheal anatomy. Distortions of underlying cartilaginous landmarks can reflect deep tumor invasion of the larynx and extralaryngeal spread. Loss of laryngeal crepitus can occur after chemoradiation and is not a definite indication of spread to the prevertebral space. Assessment of skin changes, fixation, fibrosis, and posttreatment edema and induration should be noted since this will affect plans for excision of the skin and replacement or transfer of revascularized tissue for reconstruction. Ultrasound evaluation of tissues in the neck is an increasingly popular office technique to supplement digital palpation. Palpation of the neck under anesthesia at endoscopy is more helpful than palpation in the office and can be combined with digital palpation of the preepiglottic space and base of the tongue and endoscopic instrument palpation for vocal cord fixation and involvement of the paraglottic space.

Currently, preoperative patient evaluation and clinical cancer staging are perhaps the most crucial factors in decision making in planning for total laryngectomy. Clinical classification has been codified in the American Joint Committee on Cancer TNM staging system, which takes into consideration the extent of the cancer

TABLE 29.2 Barriers to Cancer Spread in the Larynx
• Thyroid and cricoid cartilage
• Hyoepiglottic ligament and fascia
• Quadrangular membrane and thyroarytenoid fascia
• Cricothyroid membrane
• Broyles ligament
• Conus elasticus

TABLE 29.3 Preoperative Planning Issues

- Establishing the airway
- Estimation of the extent of the primary cancer
- Management of the regional lymphatics
- Management of the thyroid/parathyroid glands
- Assessment of the surgical margins
- Construction of the stoma
- Closure or reconstruction of the pharynx
- Restoration of the voice
- Nutrition
- Tobacco and alcohol use, depression, and social support mechanisms

defined by clinical examination, radiologic imaging, and functional assessments. Unfortunately, and perhaps most importantly, current measures of cancer extent do not yet take into consideration biologic parameters such as tumor growth rate, metastatic behavior or host immunity, and genetic profile. However, much has been learned through clinical correlations of patient outcomes with tumor size, depth of invasion and anatomic extension. Determinations of cancer size, invasion of laryngeal framework muscles, and risk of micrometastases have been enhanced by videostroboscopy, microlaryngoscopy, and advanced imaging with CT and PET scanning. Advanced cancers that might require primary laryngectomy would include cancers of large size, causing significantly impaired speech (vocal cord mobility), swallowing, and respiratory obstruction or those associated with clinical regional metastases. In most cases, the grouping of advanced laryngeal cancer would include patients with stage III or IV cancers, but this is not a homogenous group. In some situations such as subglottic cancers or cancers of the hypopharynx, even Stage II tumors may require total laryngectomy and thus be considered advanced, and in many cases of supraglottic cancers, even very small (T1 and T2) cancers are often associated with multiple regional metastases making them stage IV. Thus, the variability in the site and extent of cancer makes grouping patients into simple stage or site classifications difficult for selecting a primary treatment approach or for comparing the results of specific treatments in nonrandomized studies (Table 29.3).

SURGICAL TECHNIQUE

After adequate general endotracheal anesthesia is established by oral intubation or tracheostomy, the patient is prepped and draped in a sterile fashion to include the neck and upper chest and lateral thigh for possible dermal graft harvesting. Eye coverage and protection is ensured. Surgical planning is discussed including the potential need for regional or microvascular free tissue transfer for reconstruction, the need for excision of the skin of the neck, tracheostoma placement, and the need for enteral feeding tubes. Vascular access including an arterial line and a temperature-sensing Foley catheter are placed. Planning for primary or secondary tracheoesophageal shunt for voice restoration is confirmed. A second “time-out” for surgical verification and discussion of any special needs, anticipated blood loss, and the presence of required instruments and equipment is confirmed with the team. Sometimes there is a need for confirmatory endoscopy to ensure that extent of the cancer is known to confirm location for entry into the hypopharynx or for placement of feeding tubes. Instrumental palpation of compartments of the larynx and pharyngoesophageal segment can identify areas of induration that are at risk for microscopic disease. Barriers of cancer spread and expected margins are reviewed. Surgical incisions are planned.

There are a variety of incisions used for total laryngectomy. The most common is the universal or “apron” incision that consists of a bilateral, curvilinear, midneck incision that communicates with the planned skin excision for the tracheostoma. Broadening the lateral extent of this incision into more of a “utility” incision helps to minimize postoperative edema of the flap and promotes healing of the peristomal closure (Figs. 29.1 and 29.2). This incision also allows for adequate exposure of the contents of the lateral neck for bilateral selective anterolateral (levels I–IV) neck dissections. It is not uncommon to have severely damaged skin of the anterior neck as a result radiation or chronic tracheostomy. This skin of the neck is easily excised and replaced with a superiorly based transpositional cervicothoracic skin flap and the donor site below the clavicle closed primarily or grafted with split thickness skin (Figs. 29.3 and 29.4). Planning of the skin incision must reflect any needs for excision of skin and anticipate a potential pharyngocutaneous fistula that will allow diversion of saliva away from the carotid artery and trachea. If more extensive exposure of the neck is anticipated because of advanced clinical metastases or regional flap harvesting, a modified half-H (Latyschevsky-Freund) incision can be used with the horizontal limb located well above the stoma. A simple transverse incision that doesn’t communicate with the stoma can be also used for simple, narrow field laryngectomy. Such midneck transverse incisions that don’t communicate with the tracheostoma should be designed, however, to leave adequate (>4 cm) well-vascularized skin between the incision and the stoma. This bridge of the skin between the stoma and the incision helps to maintain separation of the trachea from the pharynx and if lost when a pharyngocutaneous fistula develops, makes any subsequent reconstruction difficult and creates the potential for contamination of the mediastinum.

FIGURE 29.1
Broad apron or utility incision is incorporated into design of tracheostoma.

REMOVAL OF THE LARYNX

After completion of the neck dissection(s) (Figs. 29.5 and 29.6), dissection continues cephalically to the lateral thyroid ala, which is retracted with hooked retractors. The inferior constrictor muscles are sharply transected along the lateral edge of the ala and swept laterally exposing the mucosa of the pyriform sinus (Fig. 29.5). The suprahyoid musculature is dissected free from the hyoid bone using electrocautery starting at the midline

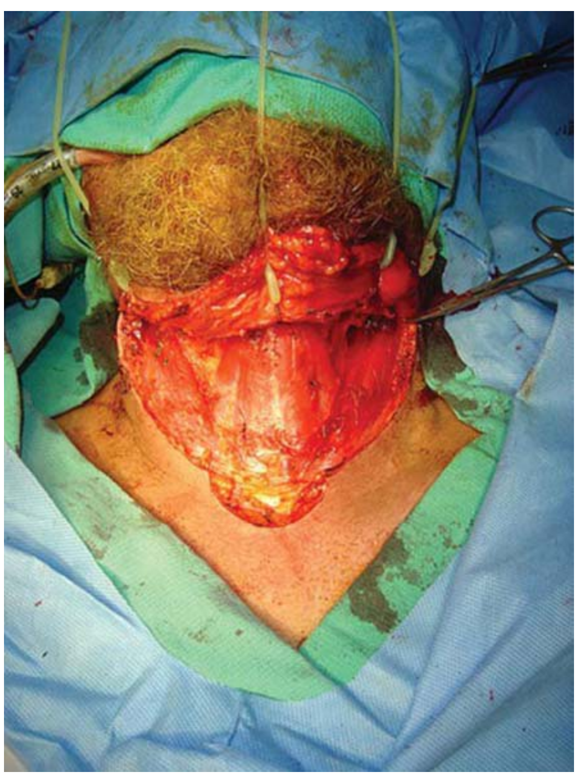


FIGURE 29.2
Elevation of skin flap.

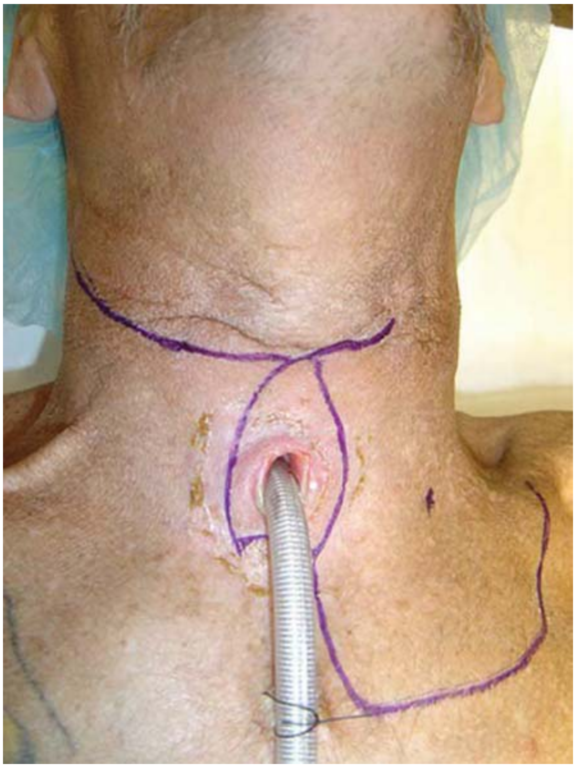
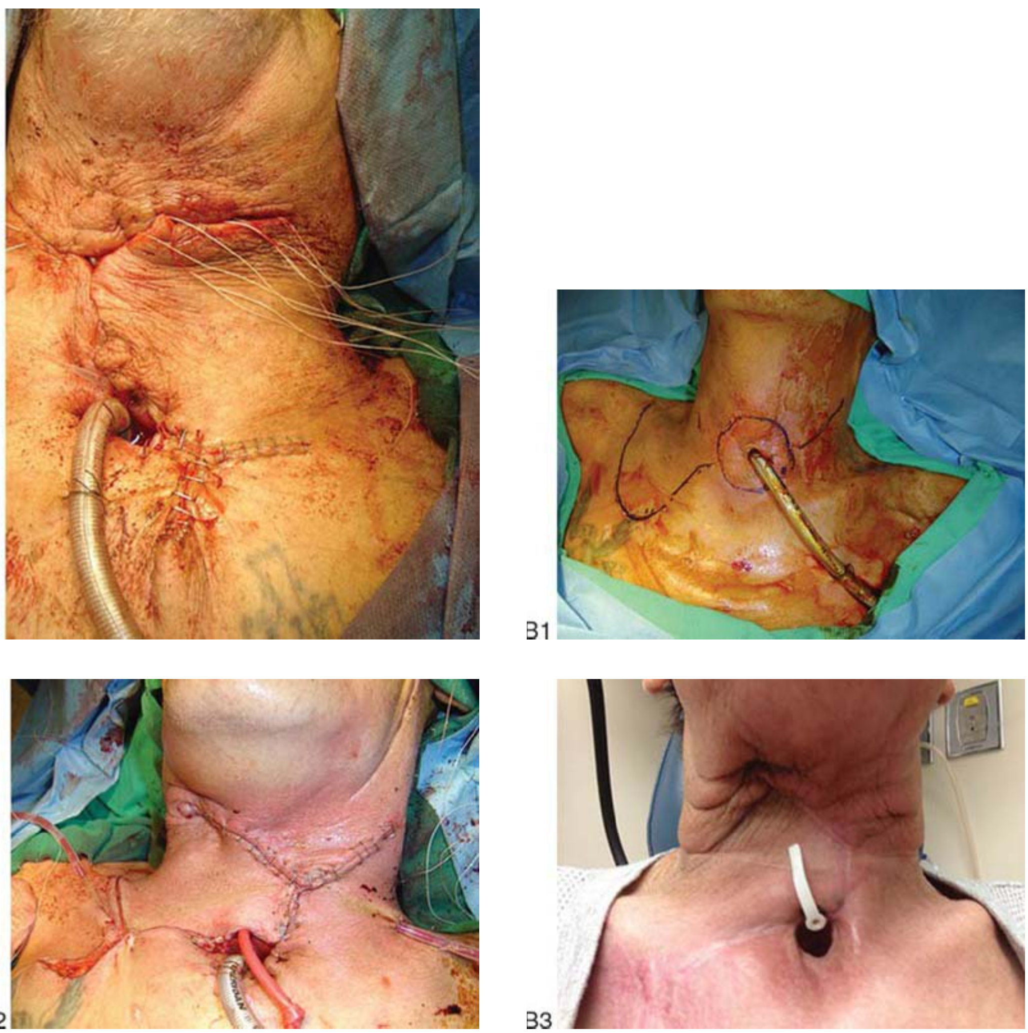


FIGURE 29.3 Long-standing tracheostomy and/or radiation damage to the skin of the neck may warrant excision of the skin and design of adjacent transpositional cutaneous or regional flap coverage.



A B1 B2 B3

FIGURE 29.4
A: Transposition flap used to resurface the neck.
B: Transposition flap used to resurface the neck (intraoperative photos and 2 months postoperatively).

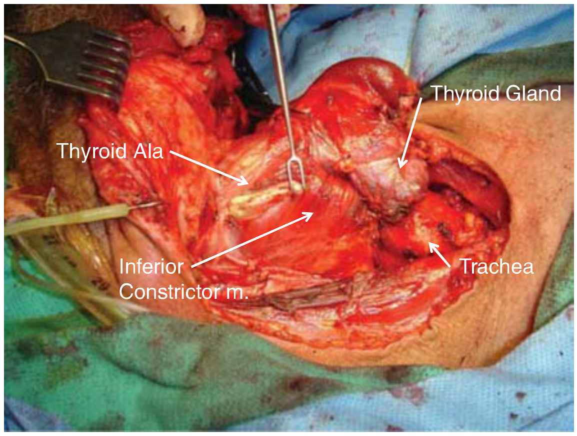


FIGURE 29.5
Skeletonization of larynx after completion of neck dissection including right lobe of the thyroid.

and extending laterally to the lesser cornua. The hyoid bone is grasped in the midline with an Allis clamp and retracted from the underlying tissues and the greater cornua dissected free using Metzenbaum or Mayo scissors "hugging" the cornua to minimize risk to the nearby hypoglossal nerve and lingual artery. This process is duplicated bilaterally. In a similar fashion, the greater cornua of the thyroid cartilage are released unless there is cancer in the pyriform sinus. If there is evidence of deep invasion of the preepiglottic space or lateral pyriform sinus, skeletonization of the hyoid, pyriform mucosa, and thyrohyoid membrane laterally is kept to a minimum on the side of involvement to avoid cutting across cancer, and these areas are resected under direct vision after the hypopharynx has been entered. At this point in the procedure, the larynx has been dissected sufficiently from surrounding tissues to allow planned entry into the hypopharynx and removal of the larynx. Based on location and extent of the primary cancer, a point of entry into the hypopharynx is selected. This point is usually opposite or at a distance from the nearest edge of the cancer. Choices for entry include the valleculae, the pyriform sinus, and the postcricoid area. For most endolaryngeal and supraglottic cancers, entry through the postcricoid area is preferred since it maximizes the amount of mucosa, which can be preserved and allows for excellent visualization of the cancer during removal (Fig. 29.7). It also facilitates direct excision of the base of the tongue and preepiglottic space. Alternatively, a contralateral pyriform sinus entry site or the vallecula entry works well for primary cancer of the glottis. Because supraglottic primaries often extend to involve the preepiglottic space, the base of the tongue, and medial pyriform, direct entry through these structures may compromise the resection. Placement of a finger or retractor into the oropharynx can help to identify safe entry into the vallecula.

Entry into the tracheal airway and management of the endotracheal tube must be discussed with the anesthesia team and preparations made prior to incisions. A sterile, reinforced endotracheal tube (armored) should be on the operative field for insertion by the surgical team. Generally the level of tracheal transection is determined by counting tracheal rings to ensure at least 2 cm of gross clearance from the inferior extent of the cancer. The wall of the trachea is carefully incised between two tracheal rings to avoid puncturing the cuff of the endotracheal tube. This can be facilitated by pushing the endotracheal tube inferiorly if possible and blunt entry made through the final layer of tracheal mucosa. The opening in the anterior wall of the trachea is carefully widened laterally and the anterior wall of the trachea sutured to the skin of the stoma site using a 2-0 Vicryl retention suture placed submucosally around a lower tracheal ring and brought out mattress fashion through the skin. If the endotracheal tube has been placed through a prior tracheostomy, the cuff can be deflated and it

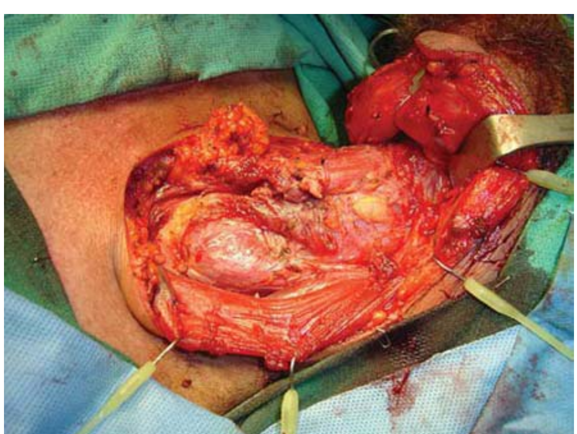


FIGURE 29.6
Completion of contralateral selective dissection with preservation of thyroid.

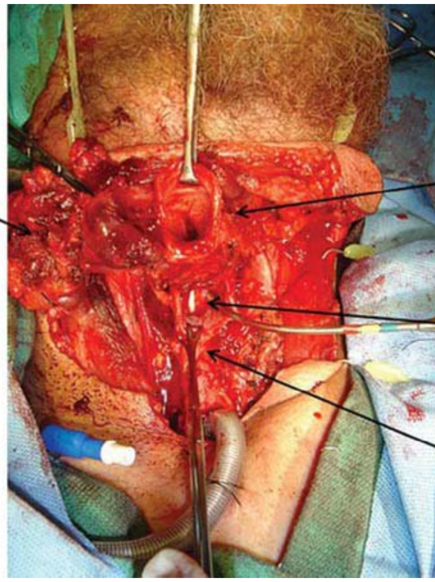


FIGURE 29.7
The larynx is entered retrograde from below by opening through the postcricoid hypopharyngeal mucosa.

can generally be moved to the new lower tracheostoma site and the cuff reinflated. If not, the anesthesiologist must deflate the cuff of the endotracheal tube and retract the endotracheal tube from the tracheal lumen under the surgeon's direct vision. Total removal of the tube from the larynx is delayed until the new armored tube is inserted, the cuff inflated and reconnection to the anesthesia circuit completed with confirmation of satisfactory ventilation, inspiratory pressures and CO_2 return. The new endotracheal tube is sutured in place. The tracheal incision is extended posterolaterally and the larynx retracted superiorly allowing visualization of the tracheal lumen and the subglottis to ensure an adequate surgical margin. Beveling the tracheal transection enlarges the stoma and helps to prevent later stomal stenosis. Tracheal margins for frozen section are obtained if there is <2 cm of clearance from the cancer. The mucosa of the posterior trachea is incised and extended into the trachea-esophageal potential space known as the "gray line." Blunt dissection allows separation of the larynx all the way superiorly to the cricoid cartilage and the level of the arytenoids. The posterior cricoarytenoid musculature is usually easily visualized. Primary cancer involving the inferior pyriform sinus or the postcricoid mucosa is a contraindication to elevating the larynx to this level. The hypopharynx is entered directly by incising the mucosa below the cricoid and opening the hypopharynx laterally (Fig. 29.7). By retracting the larynx and viewing the hypopharynx from below, lateral incisions opposite the side of tumor involvement allows the pharynx to be opened "like a book" and the laryngeal tumor inspected directly. Identifying and retracting the epiglottis is a helpful landmark regardless of the site of pharyngeal entry. Gross margins of at least 2 cm are obtained when possible and frozen section margins sent from areas closer than 2 cm.

PREPARATION OF THE PHONATORY SEGMENT, TRACHEOESOPHAGEAL SHUNT, AND PHARYNGEAL CLOSURE

Once the larynx and attached soft tissue and lymphatics are removed, adequate margins are confirmed with frozen section as necessary. The adequacy of pharyngeal mucosa for primary closure is assessed. It is important to have minimal tension on the closure and adequate blood supply to decrease the risk of pharyngocutaneous fistula, especially in previously radiated patients. Although successful pharyngeal reconstruction has been achieved with <2 cm of remaining mucosa, regional or free flap augmentation is generally preferred especially in a salvage laryngectomy. The vascularity of small strips of pharyngeal mucosa after prior chemoradiation is questionable. When there is <2 cm of residual pharyngeal mucosa, total replacement of the hypopharynx is often a preferred option. Extension of the laryngectomy to include large portions or even the whole base of the tongue will also require pedicled or free tissue augmentation. Reinforcement of the eventual closure with vascularized tissue can be helpful in preventing a pharyngocutaneous fistula.

A decision about the creation of a primary versus secondary tracheoesophageal shunt will have been made as part of preoperative planning. Palpation of the cricopharyngeus muscle is performed and if substantial muscle or muscle tightness is present, a cricopharyngeal myotomy is performed to improve pharyngeal emptying and to facilitate low pressure tracheoesophageal speech. The location for placement of a tracheoesophageal shunt prosthesis (TEP) is determined in the posterior tracheal wall by inserting a tonsil clamp in the hypopharynx. A transverse incision is made to create a tracheoesophageal communication and either a 14-Fr. red rubber catheter or a TEP is placed. Most recently a TEP has been used (e.g., Provox 10- or 12-mm prosthesis) and simplifies stomal hygiene in the perioperative period and promotes rapid voice restoration. In patients undergoing

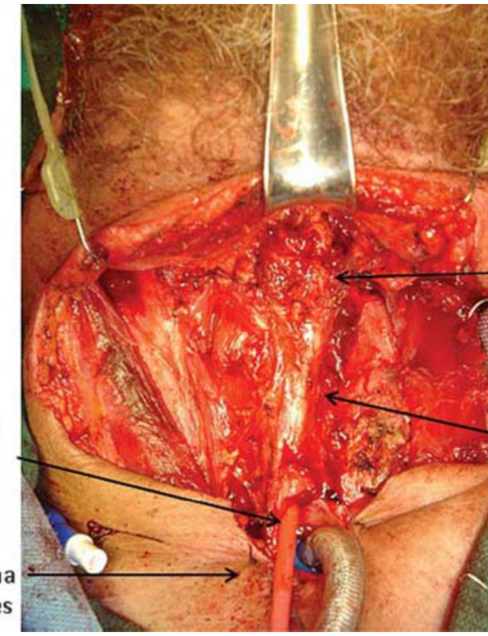


FIGURE 29.8
Closure of pharyngotomy.

primary total laryngectomy who will require postoperative radiation, the creation of a tracheoesophageal fistula is often postponed until after completion of radiation since use of the fistula for speech during or immediately following radiation is unlikely due to stomal inflammation, tenderness and tracheal mucositis and primary healing of the stoma is enhanced. Either a gastrostomy or a nasogastric feeding tube will have been placed at this point or prior to surgery. Some surgeons use the temporary red rubber catheter in the TEP site for postoperative nutrition, but this encourages excessive manipulation of the tube and stomal tissues.

Primary closure of the pharynx is performed using interrupted 2-0 or 3-0 Vicryl sutures using single layer, mattress-type Connell suture technique. When the hypopharynx has been entered in the postcricoid area, the remaining hypopharyngeal tissue is usually adequate for a single transverse closure (Fig. 29.8). The base of the tongue can be advanced to minimize tension on the closure. In other situations a "T-shaped" or "Y-shaped" closure or even vertical straight line closure may be considered. When there is adequate tissue, a second imbricating layer of Lembert-type sutures are placed or adjacent pharyngeal constrictor muscles used to reinforce the suture line. After closure, the wound is copiously irrigated and a saline pressure test using a bulb syringe in the oral cavity is performed to inspect for any area of incomplete closure of the pharynx. If the patient has been previously radiated, carotid and jugular vein coverage is augmented with muscle coverage from the SCM or levator scapulae muscle or application of a dermal graft or free tissue transfer. Generally coverage of the dermal graft is expedient and effective with the graft placed to cover both vessels if the internal jugular vein (IJV) has been also preserved. The graft is sutured to the digastric muscle and the parapharyngeal and prevertebral tissues to prevent any fistula drainage from passing under the graft.

The closure of skin to tracheal mucosa creates the permanent stoma and is accomplished in layers using several Vicryl sutures placed subcutaneously and as retention sutures placed around one or two tracheal rings submucosally and brought out through the external skin. Retention sutures help reduce tension on the closure of the stoma. Adequate skin is resected to ensure a large stoma and the lateral retention sutures can be anchored to adjacent SCM or clavicle as necessary. A meticulous final layer of skin to mucosal approximation is achieved using 4-0 chromic suture and generally results in a stoma that requires minimal postoperative cleaning or care. Any areas of exposed pieces of tracheal cartilage are meticulously covered or removed. Care is taken not to make the stoma too large, which can make occlusion for TEP speech difficult; however, this has to be balanced by the tendency for stomal stenosis to occur if prior radiation or chemoradiation has been used. Prior to final closure of the skin incision, the wound is irrigated again and closed suction drains are placed. For laryngectomy after chemoradiation, we often use modest elastic pressure dressings in addition to closed suction wound drainage to enhance primary healing of the skin flaps, which allows for early removal of the drains.

POSTOPERATIVE CARE

General postoperative care following major surgery is administered to include management of fluid and electrolytes, medical comorbidities, anemia, and any cardiopulmonary issues associated with general anesthesia. Closed suction drains are carefully monitored by the nursing staff to maintain function and prevent formation of a hematoma. Routine wound care and dressing management is standard including tracheal suctioning and

stomal cleaning as required. Supplemental humidification or oxygen is used as necessary. Soft tracheostoma stents (35 to 55 mm, 10 to 12 French) can be used if there is significant edema of the neck or a need for neck dressings. Enteral nutrition is begun when bowel activity has returned and calorie counts are performed to ensure adequate nutritional replacement. Prior vitamin and caloric malnutrition, alcoholism, and hypothyroidism are common concerns, and identification and team management of these issues including alcohol withdrawal symptoms are important. Management of such metabolic issues, anemia, and diabetes will help prevent wound complications (Table 29.4). Pain and nicotine withdrawal are managed as necessary. Speech pathology consultation and careful observation for psychological depression are instituted. Drains are removed as early as feasible (<10 mL of output per 8 hour shift over three shifts). Perioperative antibiotics (second-generation cephalosporin, beta-lactam, or lincomycin antibiotic) are used for minimum of three perioperative doses but are often continued until drains are removed. Low-dose heparin every 8 hours (with or without sequential calf compression devices) is routinely used to prevent thromboembolic phenomenon. In nonradiated cases, oral intake and suture removal are generally allowed on postoperative day 7. Suture removal and oral feedings are delayed until 14 days in radiated cases.

COMPLICATIONS

TABLE 29.4 Major Complications
• Skin necrosis/wound dehiscence/infection
• Hematoma
• Chyle leak
• Pharyngocutaneous fistula
• Pharyngeal/stoma stenosis
• Vascular complications (CVA, jugular, carotid)
• Pulmonary complications (atelectasis)
• Thromboembolism
• Hypocalcemia

RESULTS

Total laryngectomy is a very successful cancer operation because of its simplicity, intrinsic barriers to tumor spread, and generally low predilection for lymphatic and distant dissemination. However, serious complications are not uncommon and approach 50% incidence when prior chemoradiation has been administered. Major pharyngocutaneous fistulae and exposure of the great vessels (carotid, IJV) are life-threatening issues that are difficult to manage and result in long-term morbidity or death. Strictures of the pharynx are not uncommon and swallowing function is always affected by laryngectomy regardless of reconstructive methods. The severity of swallowing issues increases after salvage laryngectomy and is directly related to the extent of the resection of the pharynx or the base of the tongue and the necessity for neck dissection. When tissue augmentation of pharyngeal closure is required, a Montgomery salivary bypass tube is often used to stent and protect the pharyngeal closure, and it is removed 2 to 3 weeks postoperatively.

Five-year cure rates for total laryngectomy patients with advanced cancer of the larynx (stages III and IV) range from 40% to 60% but only 25% to 40% for secondary salvage procedures. Planned early laryngectomy for patients failing a single course of induction chemotherapy, and no radiation has been associated with remarkably higher cure rates (>80%) for these salvage laryngectomy patients. Occasionally total laryngectomy is performed in a patient who has a nonfunctional larynx following radiation therapy in order to allow oral nutrition and to prevent aspiration. These procedures are highly successful and produce excellent speech rehabilitation and significant improvement in the quality of life. It has been shown that reliance on feeding gastrostomy has a greater impact on quality of life than the presence of a permanent tracheostomy. Regardless of the simplicity of the total laryngectomy procedure, poor outcomes and high fistula rates can be expected if there are technical errors in wound closure or management, positive surgical margins, poor surgical planning, and inadequate management of the neck.

PEARLS

- Preoperative planning should include patient education, rehabilitation plans, assessment of health behaviors, and detailed analysis of the extent of the cancer including review of prior patient treatment and imaging records.
- Alcohol withdrawal syndrome and postoperative depression should be anticipated and treated.

- When pharyngeal replacement is necessary, a Montgomery salivary bypass tube is very useful and TEP should be delayed to a secondary procedure.
- The surgeon's threshold for tissue replacement should be low.

PITFALLS

- Since most total laryngectomy procedures are performed for recurrent cancer after failed chemoradiation, the most common pitfall is inadequate preoperative planning and appreciation of the extent of disease and the degree of damage to the normal tissues from prior therapy.
- Subglottic extension should be suspected if there is cricoid cartilage invasion and paratracheal dissection (level VI) should be considered. Meticulous dissection is necessary to preserve the inferior parathyroid glands and to avoid injury to the anterior jugular and innominate veins.
- Hemorrhage from a preserved IJV is a higher risk than carotid blowout if there is a breakdown of the neck wound or pharyngocutaneous fistula formation. To avoid this, aggressive fistula management, diversion away from vascular structures, and preservation of peristomal skin are essential elements of successful wound management.

INSTRUMENTS TO HAVE AVAILABLE

- A full set of major head and neck surgery instruments
- Surgical loupe magnification is advantageous.
- Endoscopy instrumentation should be available for preoperative planning or tumor reassessment.
- Bipolar cautery
- Dermatome should be available.
- A full complement of various tissue retractors including skin hooks
- Army Navy retractors
- Cummings retractors
- Small Deaver retractors are useful.
- Dobhoff feeding tube
- Voice prosthesis
- Reinforced (Armor) endotracheal tube
- Closed suction drainage catheters

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30 TRANSORAL ROBOTIC TOTAL LARYNGECTOMY

Richard V. Smith

INTRODUCTION

The treatment of cancer of the larynx has undergone considerable evolution over the past 20 years. Prior to the 1990s, patients with advanced cancer of the larynx were usually treated with total laryngectomy (TL) and postoperative radiation therapy. Currently most patients with advanced cancer of the larynx are treated with chemotherapy and radiotherapy, reserving surgery for salvage. In this situation, with a hostile local tissue environment from the prior chemoradiation, partial laryngectomy is often impractical and salvage TL is common. Salvage TL, however, is not without risk, and there are often perioperative complications, including fistula formation and its sequelae, among others. In order to minimize this risk, the routine use of flap reconstruction is recommended. Even with flap reconstruction, however, wound complications can occur, incurring additional morbidity to the patient.

Recently, transoral techniques, either robotic or microsurgical, have been recognized as appropriate methods to surgically approach select tumors of the pharynx and larynx. Transoral laryngeal surgery, albeit effective, has been limited to partial laryngectomy techniques due to limitations in reconstructive options, primarily the need for healing by second intention. These procedures, since they are transoral, have a very low risk of fistula formation, either as a primary approach or for salvage. They would be particularly applicable for salvage if adequate margins can be obtained, as the complication profile should be less, in both incidence and severity. The use of the da Vinci surgical robot (Intuitive Surgical Inc., Sunnyvale, CA) has furthered this approach by facilitating transoral suturing, allowing direct closure of the mucosa and the ability to inset a flap transorally. Therefore, procedures such as TL, which would require mucosal closure, may be performed transorally. The consideration as to whether or not a transoral approach is appropriate is the most critical step in the process. At this time, transoral TL is most appropriate for salvage laryngectomy in patients who do not have nodal metastases.

HISTORY

The patient presents with standard complaints associated with advanced laryngeal cancer, including dysphagia, otalgia, weight loss, change in voice, globus sensation, or neck mass. These are often progressive. Patients usually describe a current or former history of smoking, as well as alcohol consumption. Thorough questioning of risk factors and symptoms will help the clinician to determine the extent of disease and subsite of the larynx involved, such as supraglottis, glottis or transglottic tumor.

PHYSICAL EXAMINATION

A meticulous physical examination is necessary to accurately assess the extent and location of the tumor. This includes a requisite endoscopy and biopsy, during which the cancer must be carefully mapped and adjacent structures evaluated. This should be undertaken with the knowledge of the location and extent of the primary

cancer, to avoid overlooking potential residual disease outside the area of the obvious persistence or recurrence. A thorough understanding of the local patterns of spread of laryngeal cancer is essential in anticipating potential areas of submucosal involvement. This is one of the keys to assure resection margins free of tumor. As an example, vocal fold fixation may represent paraglottic extension of disease, raising the possibility of direct extralaryngeal extension through the cricothyroid membrane. The need for a complete assessment of the tumor and adjacent areas cannot be overstated, and such an evaluation is not possible during a routine office examination. Careful assessment of the character of the surrounding tissues (fibrosis, stenosis, telangiectasia) is important to help to identify any impediments to a transoral approach.

A main concern for transoral TL is adequate transoral access. This must be evaluated at endoscopy. Critical patient features to assess include the following: the width of the posterior mandibular arch, dentition, scarring of the oropharyngeal inlet, anterior positioning of the larynx, inferior positioning of the larynx, fibrosis of the laryngopharynx and cervical structures, and the presence of a tracheostomy tube. A narrow posterior mandibular arch will, in most cases, prevent adequate retraction of the tongue base, subsequently limiting the exposure of the vallecula and supraglottis. Most of the retractors available will not fit into such a confined space. Without anterior and superior retraction of the tongue base, transoral TL is not possible. Intact dentition, particularly the maxillary incisors, will severely limit transoral access to the larynx. Central maxillary dentition will inhibit anterior rotation of the surgical endoscope and further crowd an already limited space given the spatial needs of the operating arms, retractors, and suction instruments. Anterior positioning of the larynx has a similar effect, and inferior positioning, if one is unable to mobilize the larynx in a cephalad direction, will result in incomplete access to the hypopharynx and cricoid regions due to the geometry of the area and working depth of the current instrumentation. Fibrosis of the laryngopharyngeal or cervical tissue may similarly limit cephalic mobilization of the larynx and access to the caudal portions of the dissection. Finally, the presence of a tracheostomy, while not a contraindication, has a significant effect on the ease of the operation. The resultant fibrosis will increase the difficulty in dissection the cricotracheal region, a critical step in the procedure. In addition, if the tracheostomy has been performed by another surgeon, it is critical to know which tracheal rings were entered. It is fairly common, particularly if the tracheostomy was urgent, that the tracheal rings entered are more inferior than that anticipated by the surgeon. At this time, the retractors available for transoral access are limited, and one size does not fit all. Frequently multiple retractors, or blades, may be required to complete the operation.

INDICATIONS

The indication for this approach is a salvage laryngectomy, following either radiation therapy or chemoradiotherapy. Patients with persistent or recurrent carcinoma of the larynx confined to the larynx, with, or without, invasion of the thyroid cartilage and without lymph node disease, are those who will benefit the most from this procedure.

CONTRAINDICATIONS

Patients with cancer of the pyriform sinus, unless they are limited to the medial wall, are also not currently candidates for this procedure as instrumentation design limits access to the pyriform apex. That is likely to change as advances in instrument and robot design are made. Primary TL, which is indicated for a large T4a cancer with extralaryngeal spread, would not be appropriate for a transoral approach at this time either. Such a cancer would require resection of the strap muscles, neck dissection, and often the need for flap reconstruction, all of which would negate the current benefits of transoral TL. These indications, however, are likely to change and evolve over time.

PREOPERATIVE PLANNING

Adequate imaging is critical to preoperative planning in the salvage setting. At a minimum, this should include a contrast computed tomography scan with thin cuts through the larynx. This will help to define extralaryngeal extension, which may preclude a transoral approach. Posterior submucosal extension of the tumor is also important to define, as is the course of the carotid artery and its branches. Careful assessment of the cervical lymph nodes is essential, as the need for a lateral neck dissection may also eliminate the benefits of a transoral resection. Metabolic imaging, such as a positron emission tomography scan, will also provide important information about both the local extent of disease and cervical lymph node metastasis and is recommended where available. The application of transoral surgery should never compromise the ability to completely remove the cancer, and anatomic imaging is an important component of tumor assessment and surgical planning.

FIGURE 30.1 Stomal incision noted in the midline above the sternal notch.

SURGICAL TECHNIQUE

The optimal circumstance is one in which the patient does not have a tracheostomy in place. In that case, the patient is given intravenous sedation. After sedation, the stomal incision is outlined between the cricoid cartilage and suprasternal notch (Fig. 30.1). Subsequently, the subcutaneous and paratracheal tissues are infiltrated with 1% lidocaine/1:100,000 epinephrine local anesthetic. The skin of the stomal site is then removed and electrocautery dissection of the pretracheal tissue completed through the fascial aponeurosis of the strap muscles to expose the thyroid isthmus, which is subsequently divided and ligated. The anterior trachea is exposed from the cricoid to the fourth tracheal ring and the trachea entered between the second and third rings. An anode endotracheal tube is placed and general endotracheal anesthesia initiated. The remaining dissection through the stomal opening includes complete mobilization of both thyroid lobes off the trachea to expose the tracheoesophageal groove bilaterally. The superior tissues are similarly dissected, mobilizing the strap muscles to the level of the superior aspect of the cricoid cartilage anteriorly and to the cricothyroid muscles laterally. The posterior wall of the trachea is then incised, completing the transection of the trachea. The posterior tissues are then mobilized superiorly, separating the remaining superior trachea from the esophagus. The anterior half of the trachea is then sewn to the inferior stomal incision to mature the inferior half of the stoma (Fig. 30.2), and the remainder of the procedure, with the exception of closing the superior half of the stoma and insertion of a closed suction drain, is completed transorally.

Prior to beginning the procedure, the bed is rotated 180 degrees positioning the foot of the bed toward the anesthesia cart. A transoral retraction system, such as the FK retractor system (Gyrus Medical Inc., Maple Grove, MN) or Crowe-Davis, is used to expose the pharyngolaryngeal structures and suspended from the left side of the bed with a self-retaining Martin arm (LTL Medical, Simi Valley, CA) (Fig. 30.3). The da Vinci surgical robot (Intuitive Surgical Inc., Sunnyvale, CA) is then brought into the field and oriented 30 degrees off the patient's right shoulder (Fig. 30.4). The angled camera and telescope are inserted in the central portion of the oral cavity, with the left arm carrying a 5-mm Maryland or 5-mm Schertel forceps and the right arm carrying a spatula monopolar cautery. These are both advanced into the oral cavity obliquely, with positioning confirmed by the camera. Once all instrumentation is appropriately positioned, the assistant is seated at the patient's head to facilitate suctioning, suction cautery, clip application for hemostasis, and transoral retraction.

FIGURE 30.2 Anterior tracheal wall closed to the inferior aspect of the stomal skin to secure the airway.

FIGURE 30.3
Intraoral retractor in place suspended from the side of the bed with the Martin arm.

The resection is initiated by incising the lateral pharyngoepiglottic fold and anterior vallecula in the standard fashion used for transoral supraglottic laryngectomy. This is performed bilaterally with homeostatic clip application to the superior laryngeal vascular pedicle. The hyoid bone is dissected free from the preepiglottic tissues, maintaining the integrity of the fascial compartment containing the preepiglottic adipose tissue (Video 30.1). This plane of dissection is continued inferiorly to expose the superior border of the thyroid cartilage. Once identified, the thyroid ala is mobilized posteriorly by bluntly and sharply dissecting the fascia on strap muscles off the external surface of the alae. The outer thyroid perichondrium is left intact with the specimen as a tumor barrier. The anterior aspect of the pyriform sinus mucosa is identified and incised, continuing the dissection of the lateral wall of the pyriform sinus off the medial aspect of the thyroid cartilage. The superior cornu of the thyroid cartilage is exposed and dissected to divide its suspensory ligament. This maneuver allows access to the attachments of the inferior constrictor muscle to the thyroid ala. These attachments are then divided, mobilizing all attached musculature except the insertions of the thyrohyoid and sternothyroid muscles. These are then sharply divided along with the remaining fascia separating the superior dissection from the stomal dissection. At this point the only area preventing removal of the larynx is the postcricoid area. The postcricoid mucosal incision is made under direct visualization, providing appropriate margins of resection. Sharp and blunt dissection is used to dissect inferiorly to divide the attachments of the cricopharyngeus on each side of the cricoid. This can be facilitated through the stomal incision as well, if required. The larynx is then fully mobilized and removed transorally (Fig. 30.5).

FIGURE 30.4
Da Vinci robot brought into the field from the patient's right at 30 degrees from the bed.

FIGURE 30.5 Larynx being removed through the mouth after completing the laryngectomy procedure.

Closure of the wound is then performed. At this point, if it has not been inserted earlier, a nasogastric tube is placed under direct visualization. The wound and pharynx are irrigated and hemostasis assured. The incision is then closed with several running Vicryl sutures. The suture length is trimmed to facilitate endoscopic closure, allowing only three to four throws per suture. The pharynx is closed primarily with a single horizontal suture line. However, since the integrity of the strap muscles is maintained, if the mucosa is not sufficient to close to itself primarily, the inferior and lateral mucosal surfaces could be closed to the strap muscles in a U-shaped configuration, allowing the central component to heal by secondary intention, as is currently the standard for endoscopic resections. The area is again irrigated and inspected from the stoma to confirm a watertight closure. A suction drain is then placed through a separate stab incision into the external compartment, and the stomal suturing is completed to finish the procedure (Fig. 30.6).

POSTOPERATIVE CARE

The postoperative care of a transoral laryngectomy is the same as for a standard open laryngectomy. The notable exception is in drain management, as the drain is placed into the center of the neck through a lateral stab incision to divert saliva from the laryngectomy stoma in the case of a fistula. The drain may be successfully removed within the first several days postoperatively if there is little to no drainage and no evidence of a fistula. Meticulous care of the stoma is essential to avoid crusting, breakdown, or obstruction of the trachea by a mucus cast. Oral feeding may begin at the discretion of the surgeon but is usually safe within 3 to 5 days postoperatively. However, many of these patients will have preexisting gastrostomy tube, negating the need for early oral intake. The timing of a tracheoesophageal puncture placement is also not yet defined. The safest alternative is likely delayed, although, as with open TL, primary placement is also possible.

COMPLICATIONS

Potential complications are similar in nature to those for open TL. In theory, the risk of fistula should be decreased, with the more limited dissection involved. If one occurs, it will develop at the stoma and likely lead to dehiscence of the superior stomal suture line. If that occurs, the placement of a laryngectomy tube into the

FIGURE 30.6 Fully matured laryngectomy stoma with a single drain placed laterally.

stoma, with judicious packing of the wound, will facilitate healing of the fistula and minimizing the risk of pneumonia. Although a central fistula can be troublesome, there is little to no risk of carotid rupture from this circumstance, and the fistula can be allowed to heal secondarily.

RESULTS

Although few cases have been reported, this approach has shown similar postoperative swallowing success and oncologic efficacy as traditional "open" TL. Lower rates of fistula formation likely result, due to reduction in exposed tissues in the neck, particularly in the postradiation situation. Longer-term experience will be required to assess for stomal or neopharyngeal stenosis after this procedure.

PEARLS

- Isolate the cricotracheal complex completely through the stomal incision.
- Suture the anterior wall of the trachea to the stoma to secure the trachea after dividing it completely.
- If appropriate, perform a level VI dissection or hemithyroidectomy while isolating the cricotracheal complex.
- Dissect the posterior cricoid as far superiorly as possible through the stomal incision.
- Use as many retractors as needed to provide adequate exposure during the procedure.
- Use your assistant's two hands to facilitate the surgery—suction and retraction with additional instruments.
- Leave the hyoid bone intact if oncologically sound.
- Clip all large lateral vessels, rather than cauterizing.
- Use laparoscopic clip appliers transorally, applied by the assistant at the head of the bed, rather than transoral laryngeal clip appliers.
- Maintain as much pyriform mucosa as possible by making superior axial cuts through the mucosa and mobilizing it in a submucosal plane.
- Follow the superior thyroid cornu as cephalad as possible, releasing the attached constrictors, early in the dissection of the lateral pyriform sinus.
- Sharply divide the sternothyroid and thyrohyoid muscles from their attachments to the oblique line on the thyroid ala and stay deep to the muscles.
- Make the postcricoid incisions as cephalad as possible.
- When closing the mucosa, do so in a horizontal plane. Cut the sutures to approximately 7 cm in length before using intraorally and use as many as necessary to perform a running closure of the mucosa.

PITFALLS

- Preoperative tracheostomy can have a significant negative impact on the ability to mobilize the cricotracheal compartment.
- Severe tissue fibrosis from prior nonsurgical therapy can prevent a transoral approach.
- Significant tongue swelling may occur due to pressure from the retractors. This will resolve postoperatively without intervention.
- Always obtain the patient's consent for an open TL as well and consider the need for flap coverage in that circumstance.
- If significant lymph node metastasis is present, perform an open TL with neck dissection and flap closure.

INSTRUMENTS TO HAVE AVAILABLE

- Standard head and neck set
- Endo Stitch to secure the distal laryngeal remnant
- Intuitive da Vinci surgical robot (model S or Si)
- 5-mm instruments with Maryland grasper and spatula cautery attachments
- FK-WO mouth retractor with set of adjustable blades
- Mayo stand for suspension apparatus
- 30-degree angled endoscope
- 2-0 silk suture for tongue retraction
- Small Yankauer suction for smoke evacuation and retraction by assistant

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31 PARTIAL PHARYNGECTOMY

Giuseppe Spriano

INTRODUCTION

The pharynx has a tubular configuration. It takes part in the pharyngeal phase of swallowing and deglutition and contributes to phonation mainly by determining the resonance characteristics of the voice. Squamous cell carcinoma accounts for more than 90% of malignant tumors originating in this region. The relevant steps involved in the proper coordination of pharyngeal activity, the possible impact of surgery on the quality of life, explain why more surgical salvage procedures have been reported over the years since the 1950s adopting organ preservation protocols. However, a wide range of surgical procedures, from transoral tonsillectomy to transmandibular pharyngectomy, are still considered valid oncologic approach in the management of cancer of the oropharynx. These procedures always consist of excision of the primary cancer and neck dissection. Segmental mandibulectomy, as currently performed, was reported by Slaughter et al. and by Ward and Robben half a century ago, and the main step of the procedure has not changed.

HISTORY

Development of cancer in this region is strictly related to the use of tobacco and alcohol products and to the infection of human papillomavirus (HPV). The patient may complain of dysphagia, otalgia, or evidence of a cervical mass. The history should include information about the patient's sexual habits. The majority of patients are initially found to have stage III or IV cancer.

PHYSICAL EXAMINATION

The head and neck surgeon must perform a detailed history and physical examination of the head and neck as the first step in establishing the correct diagnosis, staging, and treatment planning of a pharyngeal cancer. This must include inspection and bimanual palpation of the oral cavity, floor of the mouth and tongue, direct fiberoptic examination of the pharynx, and laryngeal structures. Palpation of the neck is critical in the correct staging of the patient.

The patient is routinely prepared with blood samples and coagulation tests, urine tests, electrocardiogram, and chest radiography. The health conditions of the patient and the present risks of undergoing surgery under general anesthesia must also be evaluated. Low performance status and malnutrition may interfere with healing and expose the patient to infections.

Any previous surgery or radiation to the area must be taken into consideration for adequate treatment planning because it can interfere with the choice of reconstructive techniques. Blood units are screened, typed, and crossed or autologous blood is drawn if more than 500 mL of blood loss is estimated.

INDICATIONS

a. Low-stage cancers (T1, T2, N0-N1):
   1. Tumor excision (treatment of choice)
   2. Surgical salvage, in case of residual cancer after radiation or chemoradiation (selected N1 cases)
b. High-stage cancers (T3, T4a, N0-1; any T, N2-N3):
   1. Surgical salvage for residual cancer following organ preservation protocols
   2. Primary treatment
c. Recurrent cancer

Pharyngectomy for oncologic reasons must always obtain adequate cancer free margins, at least 2 cm wide because of the tendency of these cancers to have submucosal spread, to prevent microscopic residual disease (R1) at the surgical margins.

CONTRAINDICATIONS

Comorbidities and invasion of the prevertebral fascia by the primary cancer are the main contraindications to this surgery.

PREOPERATIVE PLANNING

Imaging Studies

Imaging studies include computed tomography (CT) and magnetic resonance imaging (MRI) of the skull base and neck with and without contrast. Imaging studies, particularly MRI/CT, are useful to detect invasion of the mandibular infiltration or the distance between the cancer and the mandible. CT scan of the chest will be required especially for stages III and IV cancer.

Physical examination, including inspection and palpation, remains one of the most important aspects of the preoperative evaluation. Resectability of cancer of the posterior pharyngeal wall is determined by the size and degree of fixation of the cancer. Endoscopy under general anesthesia, performed for bioptic mapping of the lesion, is considered a mandatory procedure. Radiologic evaluation of the patient includes MRI, which proves to be the most sensitive modality for tissue definition in evaluating cancers involving the base of the tongue. Diagnosis of gross tissue invasion of the preepiglottic space and the depth of infiltration into the base of the tongue may be determined by obtaining sagittal MRI scans. The high signal intensity of the preepiglottic adipose tissue can usually be distinguished from the dense fibers of the hyoepiglottic ligament, musculature of the base of the tongue, lingual lymphoid tissue, and cancer.

A barium pharyngoesophagram can often be helpful in assessing mobility of these cancers. Ultrasonography of the neck is performed to identify metastasis to cervical lymph nodes to complete the staging. CT of the chest is also done in order to detect primary or metastatic cancer of the lungs. The structure of the oropharynx and hypopharynx plays a key role in swallowing. Temporary aspiration is a predictable postoperative occurrence. The patient's functional status, especially cardiopulmonary performance, must be considered in patient selection.

SURGICAL TECHNIQUE

Effective prophylaxis is obtained by intravenous (IV) infusion of a broad-spectrum antibiotic within 30 minutes of the beginning of the surgical procedure. Nasotracheal or orotracheal intubation may be considered, when tracheostomy is not required. All patients are operated in the supine position with a pillow under the shoulder to achieve hyperextension of the head. Tracheostomy is performed at the beginning of the operation, and a nasogastric feeding tube is inserted.

If CO_2 laser surgery is being planned, precautions for laser must be carried out.

In case the transoral approach is to be used, a fiberoptic headlight is worn by the surgeon.

Surgical techniques involving the oropharynx may be categorized according to the surgical approach or the disease location (subsite[s] involved). In the former category, there are three principal approaches that can be used in performing pharyngectomy as described:

1. *Transoral*: surgical excision of the pharyngeal cancer, through the oral cavity. This approach is reserved for limited benign tumors or small, superficial cancers of the lateral, superior (soft palate), and posterior pharyngeal wall. Advances in technology using various devices such as the CO_2 laser and robotic surgery

have extended the indications for this procedure to cancers that may involve other subsites such as the base of the tongue, and valleculae, and in some cases even more advanced cancers, which may be adequately exposed and safely excised in this manner.

2. *Transpharyngeal or transcervical*: Resection is achieved by a cervical, submandibular approach, which exposes the mass through a lateral and/or anterior pharyngotomy. This approach does not allow wide exposure compared to transmandibular surgery; nevertheless, it guarantees en bloc cancer resection and neck dissection while preserving continuity of the mandible.
3. *Transmandibular*: defines all pharyngectomies achieved through the mandible—the mandible may be preserved (mandibulotomy) or excised with the cancer via a composite resection (mandibulectomy) depending on the stage ($T4a_{bone}$) and/or subsite of the cancer. The transmandibular approach allows wide exposure of the oropharyngeal lumen from the base of the tongue to the tonsil fossa and the posterior pharyngeal wall. Hence, the resection may be performed under direct visual control of the cancer, the carotid artery and/or internal jugular vein. Continuity may be maintained between the oropharyngeal resection and the neck dissection. The reconstruction is achieved by using a pedicle or a free flap.

Tracheostomy and nasogastric feeding tube are always required in transpharyngeal and transmandibular pharyngectomy but can be avoided in limited transoral procedures.

After the excision, reconstruction by means of pedicled or free flaps is performed in a single-stage procedure in order to

- Divide the pharyngeal lumen from the neck spaces
- Restore organ function as much as possible
- Support wound healing with healthy tissue transposition or transfer, particularly in case of salvage surgery following radiation or chemoradiation

Transoral Approach

This technique has been introduced at the beginning of the 20th century for removal of hypertrophy of the tonsil and since then adapted for excision of cancer involving this subsite.

Despite the effectiveness of nonoperative organ preservation protocols for cancer involving the tonsil and tonsil fossa, surgery remains a valid treatment with limited functional sequelae. Management of cancer of the oropharynx by transoral resection, and elective neck dissection, may spare the patient adverse effects of full-dose radiation therapy or chemoradiation. In addition, minimally invasive procedures, using CO_2 laser and robotic surgery, are being recognized as effective micromanipulation instruments over conventional procedures. Surgical indications for the tonsil region may differ considering the size and site of limited cancers.

The transoral approach has advantages but also very strict limitations, including a narrow visual field of operation and an angled position of the lateral oropharyngeal wall.

Pros

- Avoids an external incision
- Early recovery of swallowing function with limited neural disability
- Reduced hospitalization time

Cons

- Limited or inadequate visualization of anatomic landmarks in case of bulky tumor
- No visual control of deep neck vessels during the excision
- No possibility of performing en bloc resection of the pharyngeal lesion and neck dissection

Resection of the Posterior Pharyngeal Wall

This procedure consists of the transoral excision of limited cancers of the posterior pharyngeal wall that do not involve the prevertebral fascia and do not reach the lateral pharyngeal walls. Adequate visualization is essential when choosing this approach.

A similar setup described for resection of the tonsil is used in this procedure. The extent of the lesion must be evaluated by MRI for any evidence of involvement of the prevertebral fascia. Staging will consider retropharyngeal lymph node involvement as well.

The traditional cold knife excision has largely been replaced by devices such as monopolar cauterization, coblation, radiofrequency ablation, and CO_2 laser, which produce good hemostasis.

Description of Technique

After tracheostomy, which is always suggested for airway safety, the patient is placed in the Rose position and the lesion is visualized using a mouth gag. The margins of excision are delineated, according to the lesion (benign/malignant) that is going to be excised. The depth of the lesion is outlined, the incisions made, and blunt dissection is performed and completed along the prevertebral fascia. The specimen is oriented for pathologic examination. Once the specimen is removed, it is sent for frozen section evaluation to assure free margins of resection. Bleeding is controlled by electrocauterization, bipolar cautery, or other surgical tools such as coblation or laser.

If the defect is not reconstructed, purse string sutures are placed between the mucosa of the defect and the underlying prevertebral fascia. In other cases reconstruction is performed using a split-thickness skin graft or a microvascular free flap transfer, such as the radial forearm free flap, which is anastomosed with microsurgical technique to the neck host vessels, after bilateral neck dissection. A nasogastric feeding tube is inserted at the end of the procedure.

Transpharyngeal Approach

This technique consists of a transcervical, submandibular pharyngectomy. It has been used as the standard approach to treat oropharyngeal cancers, not involving the larynx or mandible. It is indicated for early (T1-T2) cancer of the oropharynx, T2-T3 cancer of the soft palate extending to the lateral pharyngeal wall, base of the tongue and small cancers of the posterior pharyngeal wall. Cancer extending to the vallecula, tonsil, or supraglottic larynx and large cancers of the posterior pharyngeal wall are not suitable for resection by this approach.

It is used in median pharyngectomy, via supra or subhyoid approach, and lateral pharyngectomy. The former is indicated to treat of the base of the tongue and the posterior wall, the latter to excise cancer of the tonsil and subtonsillar fossa.

Median Pharyngectomy

The suprahyoid approach is a simple technique that allows for adequate exposure of the base of the tongue and the posterior pharyngeal wall with complete tumor control, preservation of function, and minimization of cosmetic deformity. The excellent exposure of the oropharynx offers a precise macroscopic identification of tumor margins and minimizes possible injuries to vital neurovascular structures. The open wound can usually be closed primarily without the need of flap reconstruction.

The traditional excision of the tumor is being gradually substituted by more recent techniques, such as robotic surgery, which appears to be able to excise radically oropharyngeal tumors arising on the anterior and posterior walls in those cases they do not deeply infiltrate the organ.

Some authors reported oncologic success in the treatment of T3 squamous cell carcinoma of the base of the tongue with this approach together with supraglottic laryngectomy. The occurrence of delayed deglutition and chronic aspiration limits the use of the procedure to selected cases.

Description of Technique. The skin incision depends on the extension of the operation. A superiorly based apron flap or a horizontal linear skin incision in a skin crease is outlined to perform bilateral neck dissections (Fig. 31.1).

After elevating the subplatysmal flap, a suprahyoid muscle flap is harvested and rotated downward, after its dissection from the hyoid bone. The laryngopharyngeal complex is isolated to identify the vascular and neural structures. Care must be taken laterally around the greater cornu of the hyoid bone to avoid injury to the hypoglossal nerve, when it is free from disease, and the lingual artery. The preepiglottic space is dissected, keeping its connection to the hyoid bone. The lateral pharyngeal wall is exposed together with the hypoglossal nerve and superior laryngeal vessels and nerves. Superior retraction of the separated suprahyoid tongue musculature will define the hyoepiglottic ligament, which extends from its broad hyoid origin to its narrow insertion into the epiglottis. Pharyngotomy represents the key point of the procedure. It must be performed far from the cancer to avoid residual disease and neoplastic intraoperative dissemination. When the cancer is located close to the vallecula, laryngotomy in the supraglottic subsite is a safe approach to the base of the tongue. In this case, the epiglottis is removed together with the hyoid bone and preepiglottic space. When there is no involvement of the vallecula, an incision through the mucosa just above the superior edge of the hyoid bone provides entry into the pharynx (Figs. 31.2 to 31.4).

The hypoglossal nerve and lingual artery are identified and retracted laterally. A retractor is placed on the base of the tongue to draw it into the wound. When the tumor has been removed under direct visual control and adequacy of the resection has been verified by frozen section evaluation, thyroglossopexy is performed. It consists of the primary closure of the pharyngeal stump with multiple separate sutures (Fig. 31.5).

A prelaryngeal muscle flap is rotated and used to cover the pexy. The cervical wound is closed over drainage. Special attention must be paid to keep separate surgical fields between the pharyngectomy and tracheostoma, to prevent contamination of the cervical wound when the patient coughs.

The technique is modified in patients in whom the pharyngotomy is used to approach a lesion of the posterior pharyngeal wall. After the pharyngotomy is made at the level of the vallecula, in order to reduce the

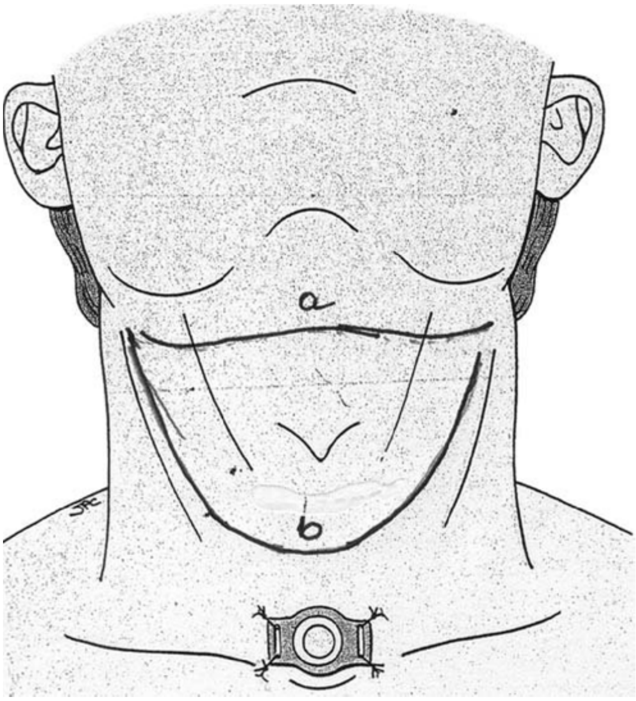

FIGURE 31.1 Skin incision (*a*) linear, (*b*) skin apron flap. In both cases, tracheostomy is kept separated.

risk of damage to the hypoglossal and superior laryngeal nerve, the cancer is identified and excised from the posterior pharyngeal wall. Frozen section control is carried out, and hemostasis is obtained. The same options for reconstruction of the defect are available in the transoral approach.

Lateral Pharyngectomy

En bloc resection of the cancer and the neck dissection is performed via a lateral transpharyngeal approach, sparing the mandibular arch. It is indicated for limited cancer of this subsite without or minimal extension to adjacent subsites, such as the base of the tongue or the posterior wall of the pharynx.

Description of Technique. The line of incision is marked from the mastoid tip to the interdigastric joint. The flap is rotated and the neck dissection is completed, including level Ib that is not dissected from the floor of the mouth and the extrinsic muscles of the base of the tongue. The internal carotid artery and jugular vein are isolated in the neck and in the parapharyngeal space, if necessary. The lingual artery is identified and ligated in the Farabeuf triangle, preserving the hypoglossal nerve, whenever possible. The superior thyroid artery may

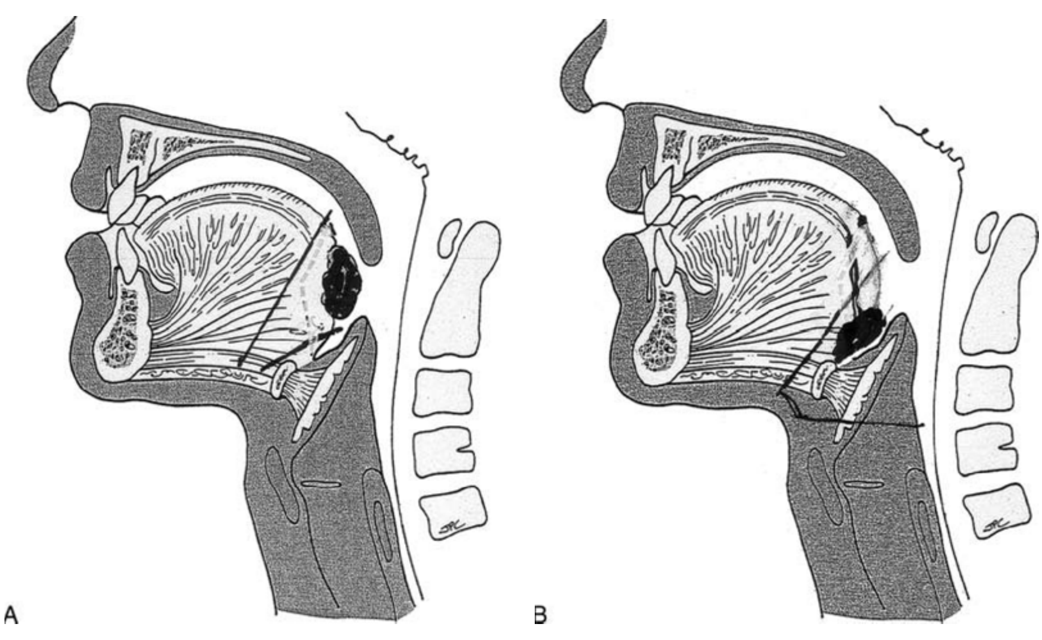

FIGURE 31.2
Type of transpharyngeal resection: **(A)** through the vallecula, **(B)** when it is free or distant from the tumor; through the supraglottic space, when the vallecula is infiltrated by or close to the tumor.

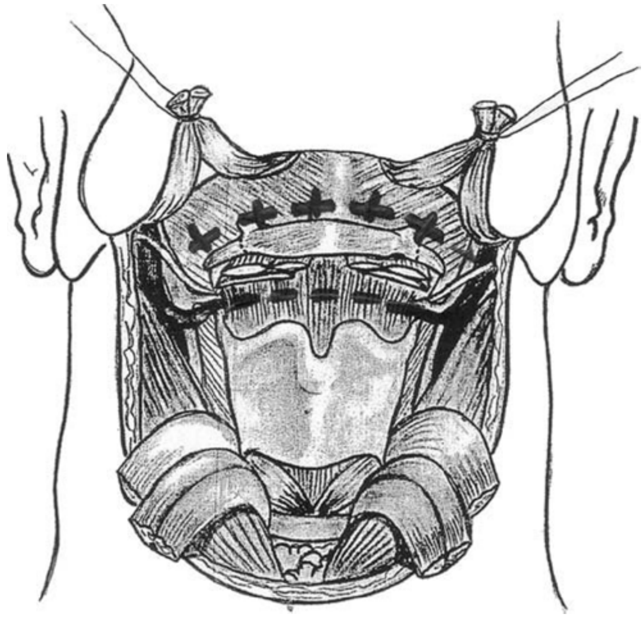

FIGURE 31.3
Inferior pharyngotomy lines: through the vallecula (*++++*); through the supraglottic larynx (----).

also be ligated and sectioned. Progressively the omohyoid muscle is resected, then the sternohyoid and thyrohyoid. The pharyngolaryngeal complex is gently dissected from the prevertebral fascia. The pharyngotomy is performed as far as possible from the tumor, usually just above the superior edge of the thyroid cartilage. The resection continues ventrally toward the posterior pharyngeal wall or dorsally toward the hyoid bone, in order to expose the subtonsil and/or the tonsil fossa from below and excise the cancer under direct visual control with free surgical margins. Frozen section examination of the specimen completes the resection phase. In very selected cases, it is possible to combine the lateral transpharyngeal approach with the transoral for cancers of the lateral pharyngeal wall. The excision may be extended to a rim mandibulectomy. The specimen is removed en bloc via a pull-through maneuver. Direct closure is achieved by positioning sutures along the pharyngeal stump. Alternative methods include by microvascular fasciocutaneous flap transfer, such as a radial forearm free flap.

In case of cancer of the soft palate, the dissection begins and is extended to the lateral pharyngeal wall. The lateral floor of the mouth is opened, and the mylohyoid muscle is incised. In this way, the resection of the pharynx is extended to the base of the tongue and completed. Closure requires the use of a reconstruction flap to achieve separation of neck spaces from the pharyngeal lumen and adequate protection of the vessels in the neck.

Reconstruction of the soft palate is complex because its muscular architecture cannot be restored. Reconstruction of hemi–soft palate defects after tumor resection is usually achieved by means of a regional flap, free tissue transfer, or a prosthesis. In case of a soft tissue defect, microvascular free flap transfer is the first choice option. Among them, fasciocutaneous flaps are recommended (radial forearm, lateral arm) (Figs. 31.6 to 31.8).

Bulkier flaps may be employed in case of major resection of the base of the tongue (abdominis rectus, lateral thigh). Pedicled flaps are indicated in selected cases and must be considered as a second choice option of reconstruction because of their poor functional results. Pectoralis major transposition is the most frequently performed pedicled flap reconstruction in these cases.

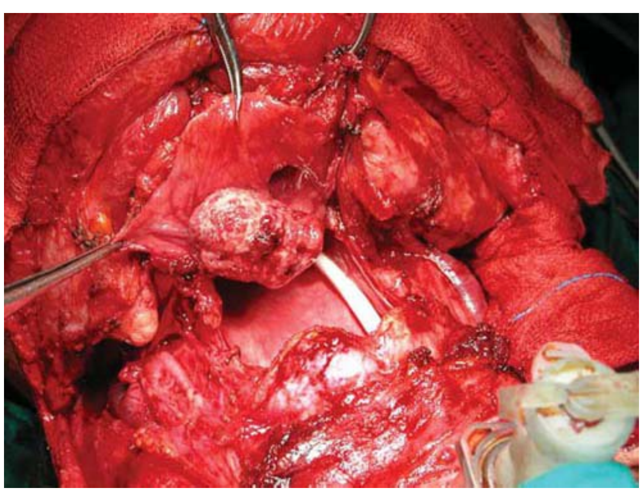

FIGURE 31.4
Transpharyngeal resection through the supraglottic space. The excision is carried out under direct visual control from the superior edge of the thyroid cartilage to the lingual "V" after laryngotomy.

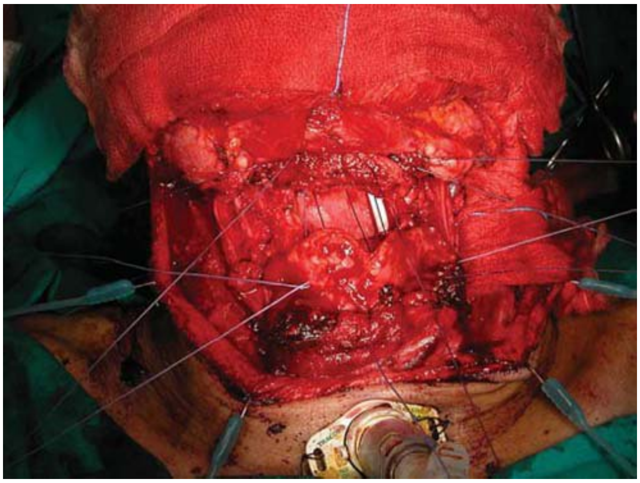

FIGURE 31.5 Multiple sutures are positioned through the margins of the pharyngeal stump.

Transmandibular Approach

Transmandibular approaches are indicated in all those cases in which wide exposure of the surgical field is required or when the mandibular arch is involved by the primary cancer or metastases to cervical lymph nodes. They are classically distinguished as "conservative" and "composite" transmandibular resections. The former consists of a pharyngectomy performed through a mandibulotomy; the latter is a composite resection of soft tissue and a segment of mandible, infiltrated by or very close (<0.5 cm/s) to the cancer.

The primary purposes of conservative transmandibular approaches are the following:

- "En bloc" excision of locally advanced primary cancer and neck dissection
- Resection of the primary cancer under visual control of the internal carotid artery and internal jugular vein in the parapharyngeal space
- Resection of primary cancers arising from the anterior pharyngeal wall (base of the tongue and valleculae) with anterior or lateral spread
- Necessity to have wide exposure of the surgical field for reconstruction by means of pedicled or microvascular free flaps

The transmandibular approaches are accomplished by

1. The conservative approach via mandibulotomy
2. The radical approach, through a segmental mandibulectomy

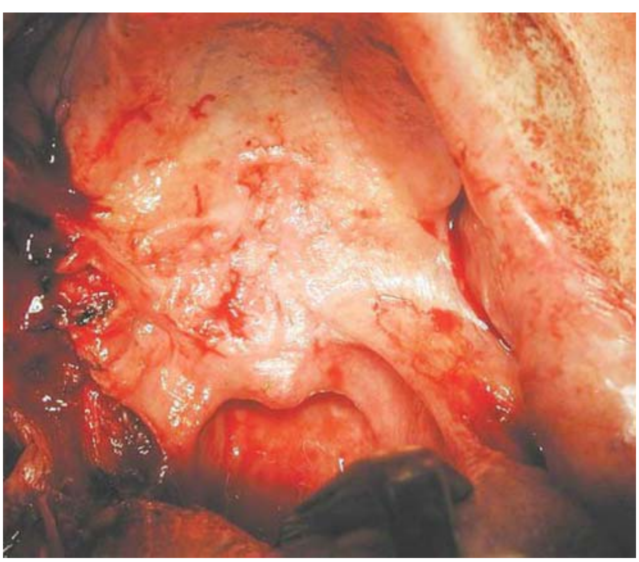

FIGURE 31.6 Cancer of the soft palate.

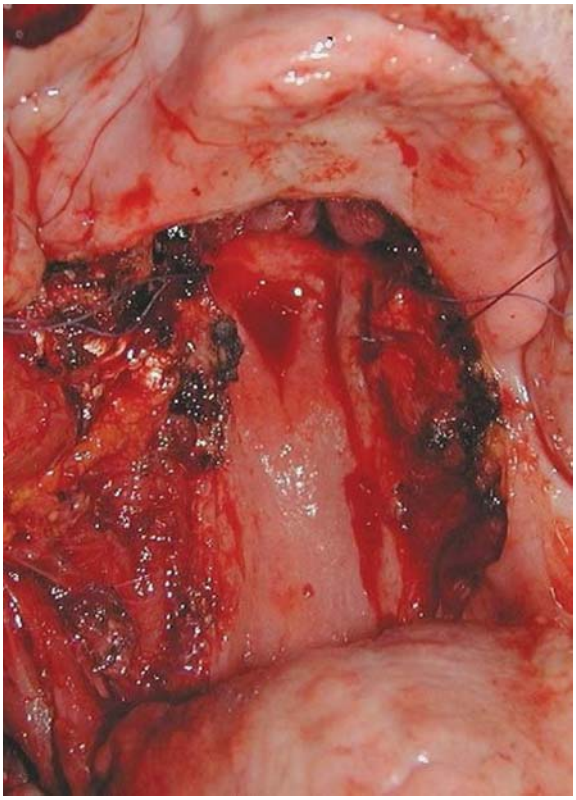

FIGURE 31.7
Surgical view at the end of the procedure: the entire soft palate and two-third of the hard palate have been excised.

The patient is placed in the supine position with a pillow under the shoulder to achieve hyperextension of the head. Temporary tracheostomy is mandatory to guarantee adequate airflow and to treat postoperative aspiration of secretions. It must be performed at the beginning of the procedure to allow the removal of the endotracheal tube and expose all the oropharyngeal lumen.

The Conservative Transmandibular Pharyngectomy

It consists of a pharyngectomy performed through a transcervical, transmandibular approach. The mandible and the muscles inserting into the mandible (pterygoid muscles) are not involved by the cancer, so segmental resection of the mandible is not required. The osteotomy preserves the continuity of the mandibular arch by temporary separation of the fragments (mandibular swing). Currently the most frequently used surgical approach is the paramedian conservative osteotomy approach between the second and third (canine) teeth. Midline conservative osteotomy via the symphysis is used as well for the midline translingual approach, as proposed by Trotter.

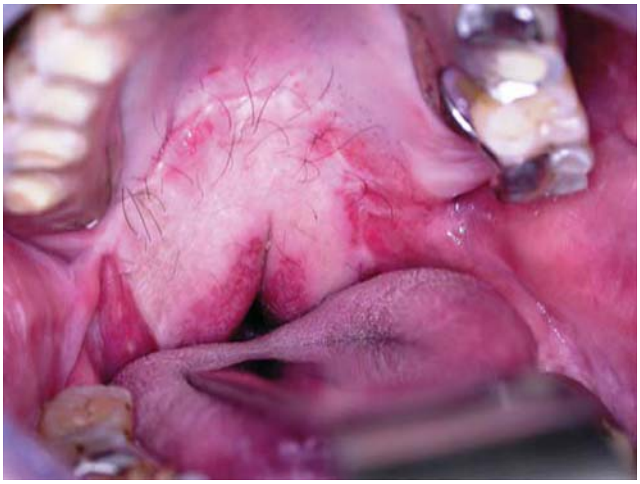

FIGURE 31.8
Postoperative view of the pharynx after reconstruction with a forearm free flap.

Paramedian Conservative Transmandibular Approach. Originally defined as a "transmaxillary oropharyngectomy via symphysis osteotomy," it was described and elaborated by many authors (Piquet, Simon, Guerrier, Vandenbrouck, Dargent).

It is indicated in the treatment of cancers invading the anterior wall (base of the tongue) and the lateral wall (tonsil fossa) of the oropharynx. The main contraindications for this procedure are invasion of the mandible and infiltration of the pterygoid muscle. In both of these cases, mandibulectomy is required to achieve a radical excision of the tumor.

Skin and Mucosal Incision. The skin incision on the lip is midline or incised in a stepwise fashion up to the midline. The incision reaches the underlying chin, which is surrounded to draw a curved line along the perimental line. A possible variant to mental skin incision is by a vertical incision in the midline. Once in the interdigastric space, it is prolonged variously in the neck, depending on the type of neck dissection required.

Inside the mouth, the incision reaches the incisor tooth socket between the second incisive and the canine dental element, passed through buccoalveolar sulcus. At that level the gingiva is sectioned to skeletonize the mandibular alveolar ridge and is prolonged intraorally along the floor of the mouth to obtain good exposure of the tonsil fossa and the base of the tongue.

Skeletonizing the Mandible. Once the neck dissection has been completed, the soft tissues are dissected in the mentum to expose the mandible. The vestibule and buccal mucosa are incised through the socket of the lateral inferior incisor or the canine tooth. The mandible at that level is skeletonized using a Joseph dissector, and the mandibular nerve (V3) is identified and preserved at the mental foramen. At the end of this phase, a 5- to 6-cm long segment of mandible is exposed transcervically.

Mandibulotomy. The osteotomy line is drawn on the mandible. Preplating is performed prior to the osteotomy through modeling titanium plates and drilling holes (Fig. 31.9).

Using the Gigli saw or sagittal saw, the osteotomy is carried out as planned. This can be performed in a linear or in a stepwise fashion to improve end-to-end approximation. Bipolar cautery and/or bone wax will control bleeding from the cut ends of the mandible.

The mandibular swing allows visualization of the floor of the mouth, which is sectioned to achieve the complete exposure of the pharyngeal cancer (Figs. 31.10 and 31.11). It is advisable to maintain mucosa attached to the mandible in order to facilitate the closure by sutures at the end of the procedures.

Resection of the Tumor. To obtain an "en bloc" resection of the cancer and the neck dissection, the mylohyoid muscles are sectioned and the stylohyoid and posterior digastric muscle plane is followed to elevate the contents of the neck dissection previously performed and the excision of the cancer. The structures of the neck, which must be preserved, such as the carotid artery, internal jugular vein, and hypoglossal nerve, are identified and gently retracted.

The dissection is performed under direct visual and palpatory control. The line of excision is drawn intraorally, keeping 1.5 to 2.0 cm/s of healthy mucosa from the edge of the cancer, and the resection is completed

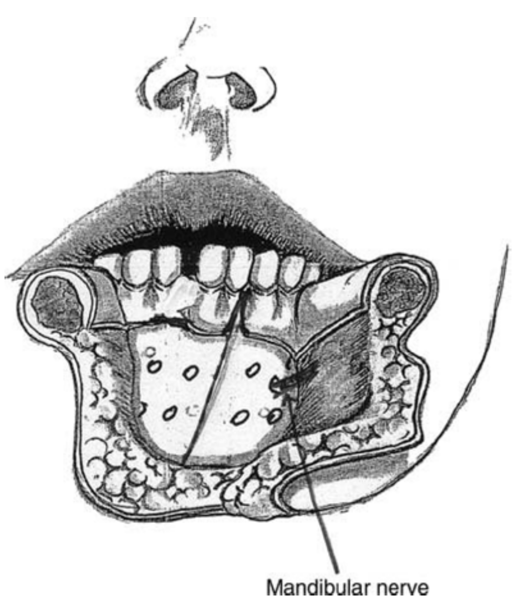

FIGURE 31.9 Mandibulotomy line. The holes, drilled during the preplating phase, are placed in order to avoid possible injury to V3 nerve by the two plates and the screws.

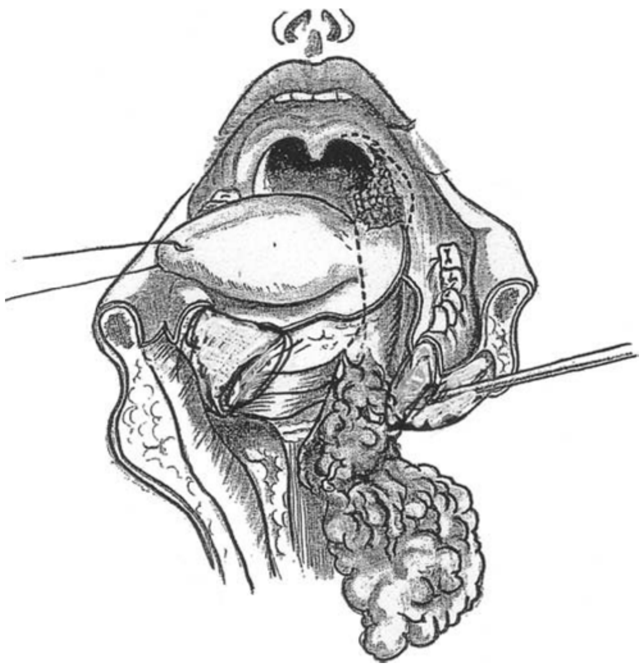

FIGURE 31.10
At the end of neck dissection and mandibulotomy, the mandibular swing permits the wide exposure of the tumor in the pharyngeal lumen and its safe en bloc excision.

both intraorally and transcervically, through the mandibular swing approach. One lingual artery may be ligated in the Farabeuf triangle to reduce bleeding, in the case of glossectomy. At least one hypoglossal nerve must be spared to guarantee adequate swallowing rehabilitation. Mucosal margins, soft tissues, and nerve fragments are examined intraoperatively by frozen section to identify any residual cancer or local spread of the cancer (Figs. 31.12 and 31.13).

Reconstruction. The reconstruction of defects that follows resection of cancer of the oropharynx is related to two main goals:

1. Anatomical separation of the lumen of the pharynx from the neck spaces
2. Functional reconstruction of the pharynx

Flap reconstruction must be reserved for those cases in which direct closure is not achievable.

Direct Closure. Direct closure consists of multiple separate absorbable sutures, which are positioned in different layers intraorally and transcervically. It is possible to perform direct reconstruction in case of

- A <50% resection of the base of the tongue
- Limited resection of the lateral pharyngeal wall

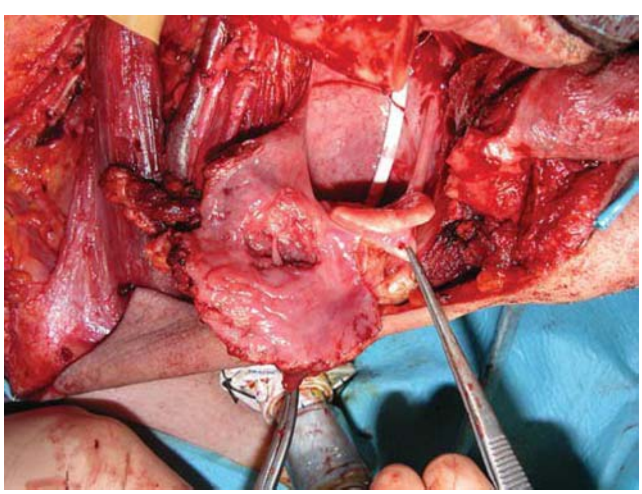

FIGURE 31.11
Excision of a cancer on the right side of the base of the tongue and vallecula is carried out.

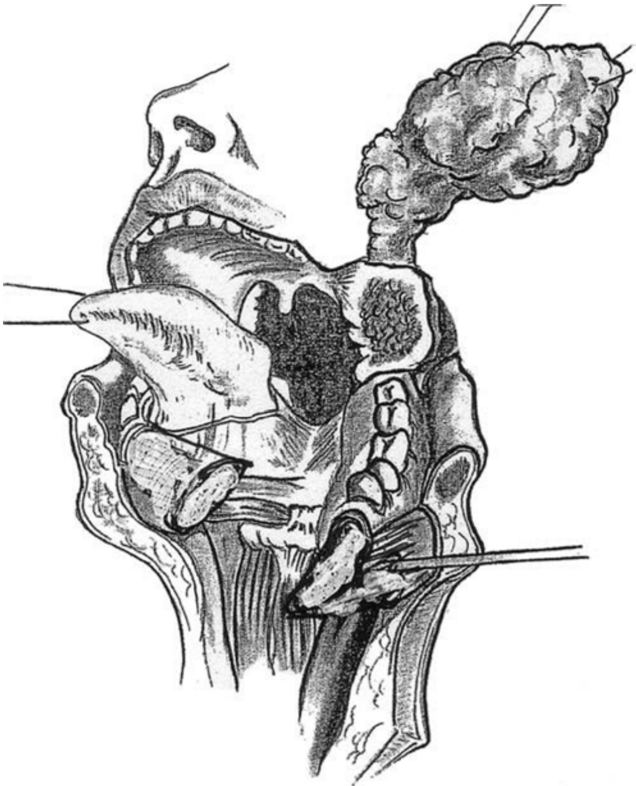

FIGURE 31.12 View of the defect at the end of the conservative transmandibular pharyngectomy.

Flap Reconstruction. It is indicated in all cases in which direct closure is not possible or there is a risk for severe anatomical or functional complications or sequelae. It is required whenever neck spaces and structures communicate with the pharyngeal lumen. Therefore, it must be performed in the following cases:

- A more than 50% resection of the base of the tongue
- A <50% resection of the base of the tongue extended to the lateral pharyngeal wall (tonsil fossa, subtonsil fossa)
- Extended full-thickness resection of the lateral pharyngeal wall

The problems related to flap reconstruction are mainly functional. The ideal reconstruction should guarantee the same volume of soft tissue (base of the tongue), motility, and above all sensitivity. Although the reconstruction

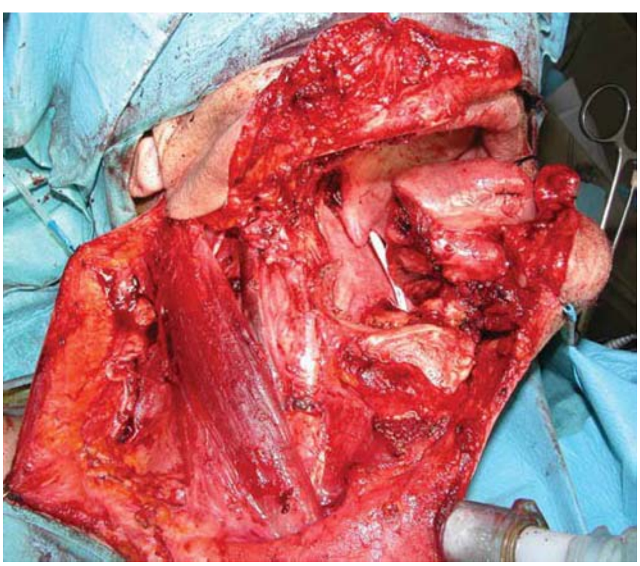

FIGURE 31.13 Surgical view: the base of the tongue, the tonsil fossa, part of the soft palate, and the epiglottis have been removed. A large defect such as this requires flap reconstruction.

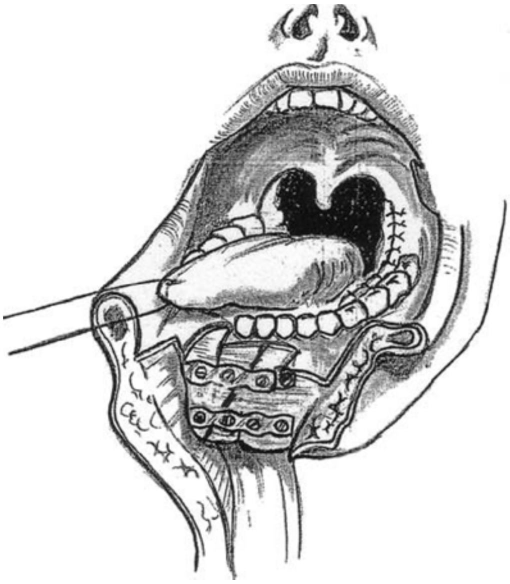

FIGURE 31.14
Direct closure following pharyngectomy. Two plates restore mandibular continuity.

procedures through microvascular flap transfer and pharyngeal reconstruction very often achieve good anatomical, static repair of the organ, it hardly ever succeeds in functional recovery. Therefore, swallowing rehabilitation tends to improve the motor activity of the residual pharynx.

Another indication for flap reconstruction is salvage surgery after chemoradiation treatment. Free tissue transfer or transposition offers safer and better healing, thanks to the positioning of healthy tissues.

Currently, flap reconstruction comprehends microvascular flap transfer as the first option, a regional pedicle flap as a second option, particularly in case of salvage treatment after radiation or chemoradiation and in patients with poor performance status. The former permits the choice of different kind of flaps, considering their thickness, extension, lack of bulky pedicle, and the possibility of sensory harvesting. The latter guarantees adequate cover and anatomical reconstruction by the transposition of a soft tissue paddle.

Osteosynthesis and Closure. Mandibular continuity is obtained via osteosynthesis using titanium plates and screws secured in the previously prepared holes at the bone ends (Fig. 31.14). Approximation of the buccal mucosa in the gingivobuccal sulcus, the vermilion border, and the skin is performed for final closure. Drains are positioned in the neck, far from the mucosal sutures.

The Composite Transmandibular Pharyngectomy

Segmental mandibulectomy, generally named "commando operation," acronym for combined oral mandibulectomy, consists of the removal of a segment of the mandible performed in the setting of a composite resection, in continuity with the oropharyngeal cancer.

Cancer arising in the lateral or anterior wall of the oropharynx may invade the mandible. Mandibulectomy is indicated in the presence of invasion of the mandible or in those cases in which the cancer is so close to the mandible that its excision is at risk of residual disease if bone is preserved. For cancer of the pharynx, it mostly occurs when there is invasion of the pterygoid muscles.

In addition to careful examination under anesthesia by bimanual palpation, radiographic evaluation of the mandible should be available for satisfactory preoperative planning.

Skin Incision and Cervical Flap. Depending on the type of neck dissection and the extension of the operation a visor flap (an upper neck incision 2 to 4 cm below the mandible) or a lip-splitting incision is performed. Whenever it is possible, any facial and particularly labial incision should be avoided especially in the case of salvage surgery for radiation/chemoradiation failures (Figs. 31.15 and 31.16).

Skeletonizing the Mandible and Pharyngectomy. After the neck dissection is completed, the inferior mandibular ridge is exposed and a subperiostial dissection of the external cortical side is completed, sectioning the masticatory muscles and displacing the parotid gland up to the coronoid process.

The endoral phase of the procedure must consider the site of the cancer of the oropharynx. The mucosal incision of the gingivobuccal sulcus, which should be performed close to the gingival ridge, must be performed at least 2 cm from the border of the cancer. Now the cheek flap may be elevated exposing the segment of the mandible and the oropharyngeal lumen. The dissection of the soft tissue aspect of the cancer continues under

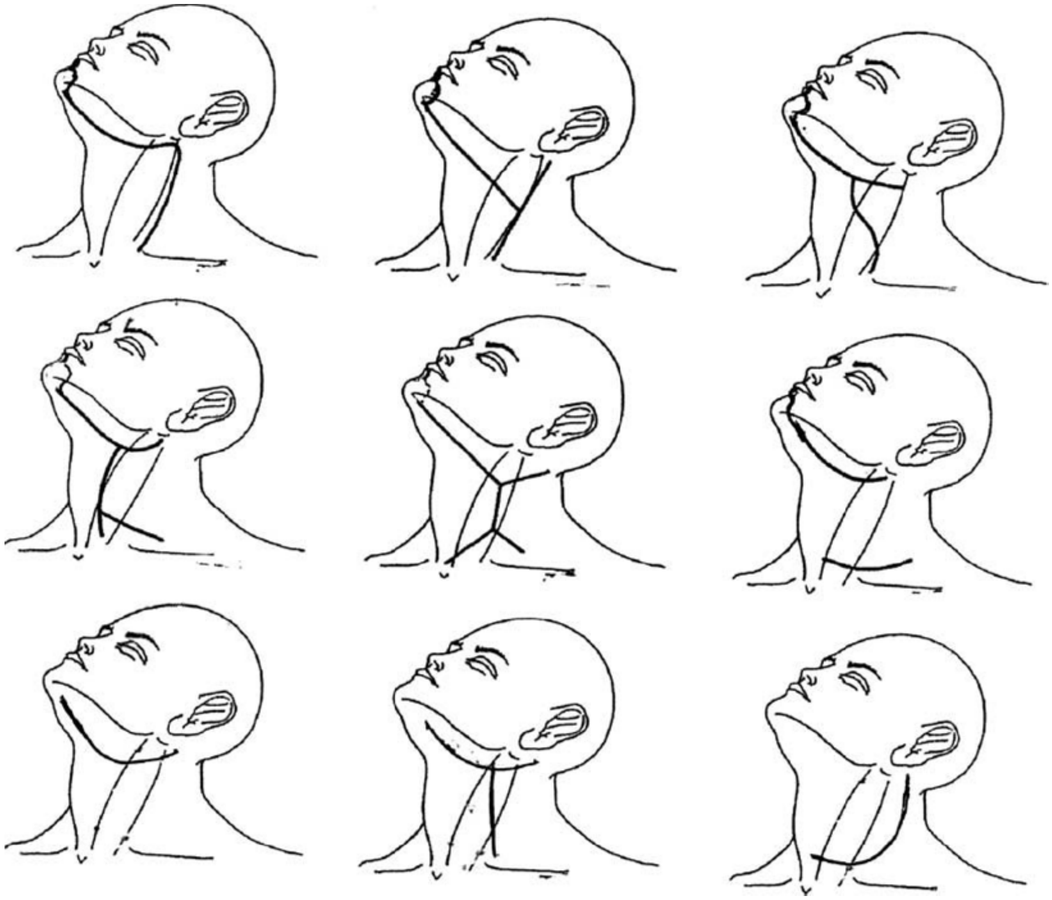

FIGURE 31.15 Skin incisions for composite resection and neck dissection.

direct visual control. Using electrocautery, the mandible is completely isolated from soft tissues along the two osteotomy lines, both in its external and internal sides.

Mandibulectomy and Composite Resection. The segmental mandibulectomy must include the mandibular channel and its ostium at the level of the spina mandibulae, to achieve the radical excision of the mandibular nerve lymphatics. It must be performed as far as possible from the area of the mandibular invasion. This is why

FIGURE 31.16 Lip sparing skin incision for composite resection and neck dissection. It is possible to see the Gigli saw positioned at the mandibular resection extremities and neck dissection.

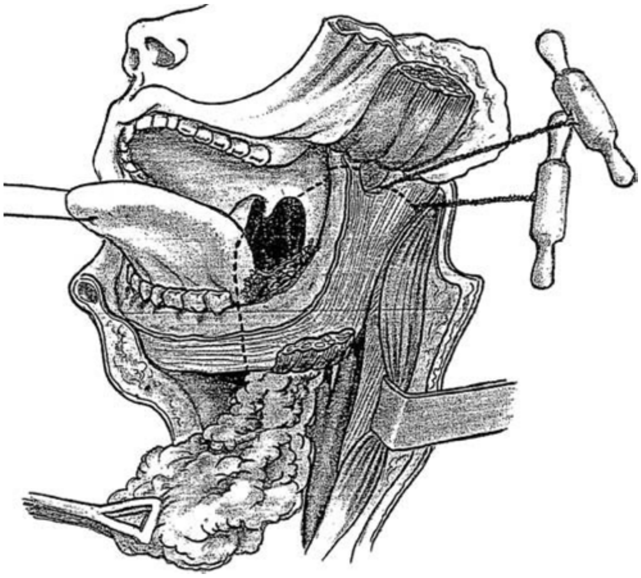

FIGURE 31.17
Mandibulectomy by using a Gigli saw. It is performed after the neck dissection is complete.

the mandibular resection, including the whole ascending ramus branch up to the condyle, may be required. Osteotomy may be performed by means of Gigli saw, oscillating or sagittal saw (Fig. 31.17).

The excision of the soft tissue part of cancer is now completed transcervically under direct visual control, displacing and retracting the mandibular segment. At the end of the excision phase, the specimen is composed of the cancer, the mandibular segment, and the neck dissection (Fig. 31.18).

Reconstruction. It must be planned preoperatively in order to achieve adequate functional and aesthetic results. The reconstruction at the end of a composite resection must consider either soft tissue or bone continuity restoration. Fibula and iliac crest osteomuscular microvascular free flap represent the preferred procedures in the literature, in relation to anatomical, aesthetic, and functional outcome and donor site morbidity.

POSTOPERATIVE MANAGEMENT

Parenteral hydration is given during the first 24 to 48 hours together with broad-spectrum IV antibiotics. Negative pressure drains are used in the neck. The tracheostomy tube is usually kept in place for 5 to 7 days. The nasogastric feeding tube is maintained until the patient is able to swallow without any risk of aspiration and

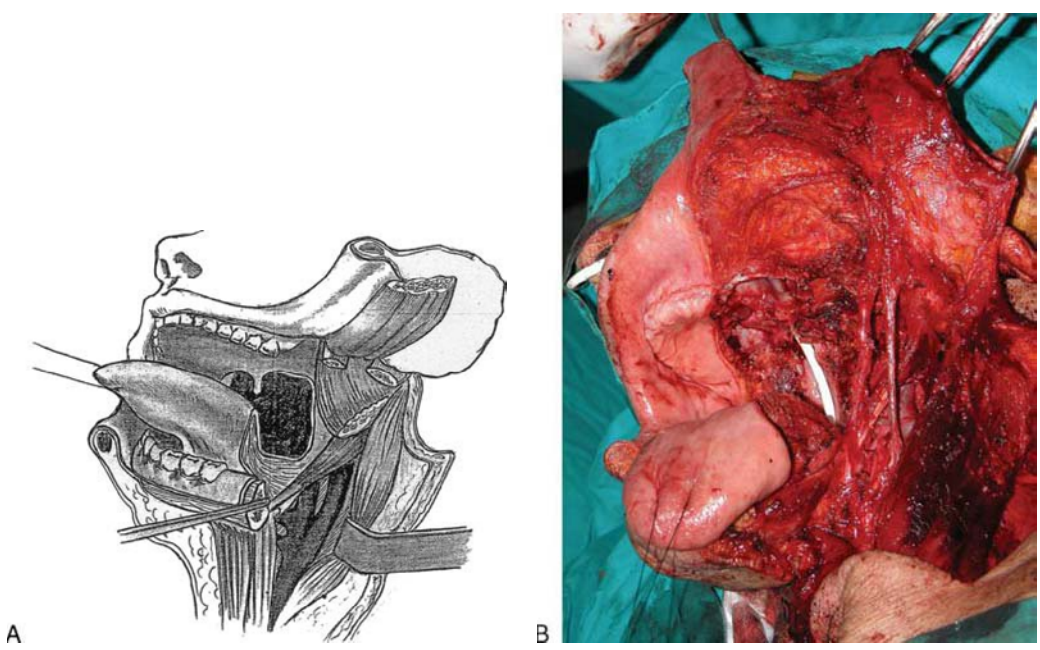

FIGURE 31.18
A,B: Surgical field at the end of the excision phase. The pharyngeal lumen is in continuity with the neck and parapharyngeal spaces.

when the integrity of the mucosal suture lines can be ascertained by administration of colored juice by mouth, after which the physician can observe the cervical drains for evidence of a pharyngeal fistula.

COMPLICATIONS

Postoperative complications may be distinguished as local and/or general: the former are usually infections. Infections may be secondary to poor oral hygiene, metabolic disease (diabetes, hepatitis), and circulatory disease dehabilitation. Tissue dehiscence may occur at the level of the oral pelvis, where tension on the suture line is more common, due to the traction of the residual tongue and secretions that tend to filter among sutures. Infections and dehiscence may determine the formation of a fistula between the oral cavity and the neck, usually along the cervical incision in the second level. Infection of the mandible at the level of the osteotomy line and the screw holes represents one of the most serious complications of this procedure. Surgical treatment of tissue dehiscence, nasogastric tube feeding, and antibiotic therapy are the main tools to treat these problems. Other postoperative complications may be represented such as bleeding, hematoma, aspiration pneumonia, and flap failure, when it is used for reconstruction. In case of mandibulotomy or mandibulectomy with bone reconstruction, plate exposure has to be considered if soft tissue is not sufficient or infection occurs. Osteomyelitis, bone necrosis, and malocclusion can present following the transmandibular approach.

PEARLS

- Involvement of the prevertebral fascia and/or the carotid artery (>270 degrees) by cancer is a contraindication to surgery.
- Preplating the mandible before resection can assist in accurate reconstruction and occlusion.
- Preserve dental roots during mandibulotomy.
- Decannulation is achieved when there is no risk of airway obstruction and before removal of the nasogastric tube and initiation of oral feeding.

PITFALLS

- Frozen section analysis of bone margins is not a possibility, so a generous margin of bone must be taken to avoid positive surgical margins.
- The success of free flap reconstruction depends on excellent nursing care.
- V_3 injuries should be avoided elevating the skin flap at the level of the mandible.
- Fistula and dysphagia are often caused by tight closure due to inadequate residual mucosa.

INSTRUMENTS TO HAVE AVAILABLE

- Mouth gag
- Monopolar cautery
- Gigli saw
- Screws
- Mini plates

SUGGESTED READING

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32 TOTAL LARYNGOPHARYNGECTOMY

Fausto Chiesa

INTRODUCTION

Treatment of cancer of the larynx is particularly challenging due to the need to combine cure with preservation of laryngeal function, the loss of which has a major impact on people's communicative and functional skills in society. For this reason, major research efforts have, in recent decades, been dedicated to the introduction of treatment modalities that allow preservation of the larynx. In fact total laryngopharyngectomy (TLP) nowadays seems to play a restricted role in the management of untreated laryngohypopharyngeal cancer because of the progressive increase of nonsurgical "organ preservation" protocols and conservative surgical approaches, even though Hoffman in 2006 reported a decreasing survival rate among patients with laryngeal cancer during the last two decades in the United States. These unexpected results might be explained by the increasing use of such nonsurgical conservation treatment modalities.

Nevertheless, TLP remains, today, the main treatment modality employed in laryngohypopharyngeal diseases such as advanced squamous cell carcinoma (SCC) or other nonepithelial rare tumors of the larynx with massive invasion of the cartilage framework, in recurrences after failure of chemoradiotherapy or after conservation partial laryngectomy, in an emergency procedure in airway obstructive tumors, or in rare complications of previous treatments (e.g., chondroradionecrosis) or, finally, for advanced T3-T4 subglottic cancers.

The first total laryngectomy (TL) was performed by Billroth in Vienna on a 36-year-old man with a subglottic tumor who originally underwent a hemilaryngectomy on November 27, 1873, and a successive TL on December 31, 1873. He was discharged on March 1874 but expired 7 months after surgery from metastatic cancer. In 1875, Bottini performed the first primary surgical treatment by TL, in Italy (Turin): the patient, with a diagnosis of laryngeal sarcoma, survived for 15 years after surgery. In the early 1900s, the complete separation of the airway from the digestive tract, suturing the trachea directly to the cervical skin to create a stoma and a primarily closed pharynx, was performed by Gluck in Europe and Solis-Cohen in the United States.

In 1909, Finzi reported good results with the use of external beam radiation therapy for cancer of the larynx. At the Curie Foundation in Paris, during the 1920s, Coutard treated patients with cancer of the tonsil, larynx, and hypopharynx with radiotherapy. Between 1920 and 1950, radiotherapy became the treatment of choice for cancer of the larynx. After 1950s the modern "wide field" TL combined with neck dissection became the treatment of choice for advanced or recurrent cancer of the larynx.

The evolution of clinical tools and techniques from Garcia's indirect mirror laryngoscopy to the modern videolaryngoscopy and dedicated imaging with computed tomography (CT) or magnetic resonance imaging (MRI) have improved current clinical evaluation and treatment planning. All of these have formed the basis of today's progressive increase in conservation partial laryngectomy approaches (e.g., endoscopic, supracricoid, or supraglottic laryngectomy) and nonsurgical "organ preservation" protocols, such as neoadjuvant chemotherapy followed by radiotherapy or concomitant chemoradiation, and have thereby limited the role of TL in the management of cancer of the larynx and hypopharynx.

The current recommendations for the management of advanced cancer of the larynx are described in the National Comprehensive Cancer Network practice guidelines.

HISTORY

Before proposing laryngeal surgery, the patient's history should be carefully collected. The presenting symptoms, such as dysphonia or dysphagia, should be investigated. Concomitant lung, mediastinal, or esophageal cancer must be excluded. The patient's habits should also be collected: the relationship between laryngopharyngeal cancer and smoking, alcohol, and diet has been known for many years. A previous history of cancer of the head and neck or other malignant tumors is mandatory to know, since previous radiation treatment can compromise the wound healing of the neck region after laryngopharyngectomy. The history of heart disease, hypertension, chronic obstructive pulmonary disease, diabetes, or other comorbidities has to be investigated, because they can influence the perioperative period.

PHYSICAL EXAMINATION

Accurate clinical staging of cancer of the larynx/pharynx is the key to success in its management. This includes inspection of the larynx, palpation of the neck, flexible video-fiberoptic pharyngolaryngoscopy. In some cases, direct microlaryngoscopy under general anesthesia may be useful. One notes any hoarseness or roughness suggesting involvement of the vocal cords or a toad-like voice suggesting supraglottic involvement. Any airway obstruction is noted, and plans should be made to alleviate the obstruction.

Palpation of the neck may reveal the presence of metastatic lymph nodes. Note should be made of any lack of mobility of the larynx with respect to deep structures. The second step of clinical evaluation is video-assisted fibrolaryngoscopy. This is mandatory for a thorough evaluation of the local extension of the lesion; it is important to determine the mobility of the arytenoids, the respiratory space, and subglottis extension of disease. The pharynx and hypopharynx are examined for extent of tumor involvement.

INDICATIONS

TLP remains, today, the main treatment of cancer of the laryngohypopharyngeal complex in the following cases:

- In advanced resectable SCC of the larynx and hypopharynx, rare epithelial tumors (e.g., adenocarcinomas, tumors of salivary gland origin), or other nonepithelial malignancies (melanomas, fibrosarcomas, chondromas, chondrosarcomas, and paragangliomas) of the larynx with massive invasion of the cartilage framework
- In advanced resectable hypopharyngeal cancers with massive laryngeal invasion or spread across the postcricoid region
- In recurrence/persistence of cancer following chemoradiotherapy
- As completion surgery for failed conservation partial pharyngolaryngectomy
- In an emergency procedure in tumors causing airway obstruction or in rare complications of previous treatments (e.g., chondroradionecrosis)
- For advanced subglottic cancers with or without infiltration of the cricoid cartilage

CONTRAINDICATIONS

The major contraindications to TLP are tumor-related and patient-related factors. Cancer-related factors include laryngopharyngeal cancer with invasion of the prevertebral fascia, massive tracheoesophageal invasion, continuity between primary cancer and neck metastases, fixed metastatic lymph node, fixation of the larynx, involvement of the common or internal carotid artery, and presence of distant metastasis or incurable synchronous cancer. The patient-related factors include patient desire, age, and severe comorbidity that contraindicates major surgery. In these cases, it is preferable to carry out a tracheostomy, with percutaneous gastrostomy and palliative/supportive care.

PREOPERATIVE PLANNING

Clinical staging of the patient must be completed by imaging evaluation that includes CT, MRI, and positron emission tomography–computed tomography (PET-CT) scan. MRI is especially useful in detecting any involvement of the preepiglottic and paraglottic spaces, infiltration into cartilage structures, as well as submucosal spread of disease. Finally, the PET-CT scan may reveal distant metastases or other possible synchronous cancers, which severely impact patient survival.

Direct Microlaryngoscopy

Direct microlaryngoscopy under general anesthesia is another clinical staging procedure that is used for determining the histology by biopsy, evaluation of cancer extension, and "mapping" of the lesion. This procedure, used widely in the past, is losing its mission due to improvement of diagnostic tools such as flexible video laryngoscopy, high resolution of diagnostic imaging, MRI, and CT scan that make the most accurate evaluation of not only the superficial extension but also the deep extension of the cancer. Ultrasound-guided transcutaneous Tru-Cut biopsy under topical anesthesia in the outpatient office makes for a reliable histologic diagnosis of the suspect lesion, especially in those patients who have previously been treated by radiotherapy or chemoradiotherapy. In those patients, there are usually some problems regarding intubation and laryngeal exposure due to the side effects of chemoradiation, which require a preliminary tracheostomy.

In the case of dysphagia or when the lesion clinically involves the hypopharynx, or the retrocricoid area or pyriform sinus, an esophagoscopy is recommended. This will provide information as to when the cancer of the pyriform sinus infiltrates inferiorly into the cervical esophagus.

Other factors must be considered in surgical treatment planning for cancer of the larynx and hypopharynx. These include age, sex, comorbidity, location of the cancer, previous treatment, metastases to the neck, and staging. In cancer of the larynx and hypopharynx, the cervical nodes at risk are levels II, III, IV, and VI. Cancer of the supraglottis and hypopharynx is frequently understaged due to the presence of submucosal spread. The supraglottic area has a rich lymphatic network, and about 50% of such cancers, irrespective of stage, metastasize to bilateral cervical nodes.

About 70% of cancers of the larynx originate at the glottic level. Such cancers have a low incidence of lymph node metastasis in early stages (T1-T2), this incidence being <10%, whereas in more advanced stages (T4 with involvement of the hypopharynx), the reported incidence is approximately 30%.

Primary cancer of the subglottis is unusual, representing <3% of cancers of the larynx that tends to be bilateral or even circumferential at presentation with early invasion of the cricoid cartilage; generally it has an extralaryngeal extension anteriorly through the cricothyroid membrane or inferiorly into the trachea. It also metastasizes to the lymph nodes in level VI. Submucosal extension in hypopharyngeal cancer is often underestimated at clinical examination. Cancers of the hypopharynx have a high incidence of metastasis to cervical lymph nodes and the highest incidence of distant metastases when compared to other sites in the head and neck.

The preoperative planning should be based on clinical staging. Generally, for moderately advanced cancers of the larynx that have limited invasion of hypopharyngeal structures, TL with partial pharyngectomy is adequate since there is a sufficient strip of pharyngeal mucosa remaining for reconstruction. However, for lesions located in the inferior part of the hypopharynx or for locally advanced cancer of the larynx, a TL and a circumferential pharyngectomy are indicated. If a strip of mucosa of the posterior pharyngeal wall has been preserved, reconstruction with a myocutaneous flap is indicated. After a complete circumferential laryngopharyngectomy, the microvascular jejunal free flap is considered the optimal reconstructive option, even though the anterolateral thigh or radial forearm is considered a good choice, since they avoid opening the abdomen. When the pharyngolaryngectomy is extended to the esophagus, the defect can be reconstructed by mobilizing the stomach into the neck; this procedure known as a "gastric pull-up" involves three different surgical fields and is associated with a high morbidity and hospital mortality and poor quality of life.

In advanced stages of cancer of the larynx and hypopharynx, a selective neck dissection is always recommended (generally levels II-V and VI) and it can be associated with a hemi- or total thyroidectomy. Bilateral neck dissection should be performed in patients with positive bilateral neck involvement, in cases where there are massive cancers of the supraglottis or advanced cancer of the hypopharynx. Central neck dissection is recommended in cancer of the hypopharynx and in cancer of the larynx with subglottic extension. Stomal recurrence is a highly negative event because it results in a poor survival rate. The reported incidence of stomal recurrence ranges from 2% to 25%, and generally no surgical treatment is suggested in advanced stages even though sometimes, in accordance with Sisson classification, extensive surgical resection is needed. In the rare nonepithelial malignancies (e.g., chondromas, chondrosarcomas), a neck dissection is generally not suggested because of the low rate of metastasis.

Regarding salvage surgery after radiation or chemoradiation failures, which is increasingly common, preoperative planning must take into account the high incidence of postoperative complications (e.g., pharyngocutaneous fistula, wound dehiscence, infections, and bleeding). Reconstruction with flaps is generally suggested. In these patients, undertreatment could compromise oncologic outcome and overtreatment could increase postoperative complications.

TECHNIQUE

The operation can be summarized in five steps, starting from the incision of the neck going through the mobilization of the larynx, resection from the trachea, removal of the larynx and pharynx, and closure with flap repair of the neopharynx.

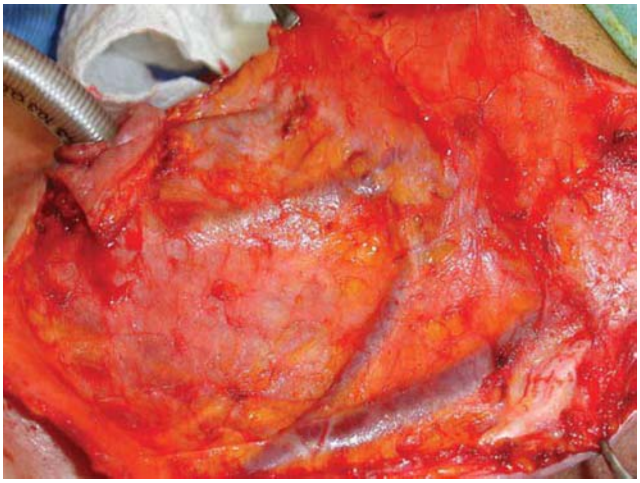

FIGURE 32.1
The "apron flap" incision allows both good access and cover for the pharyngeal suture line.

The neck incision, using a cold knife, should provide good exposure not only of the laryngopharynx but also of the laterocervical compartment if a neck dissection or an extended laryngectomy has to be carried out. In planning the incision, one should also provide for the necessity of enlarging the excision to other structures such as the base of the tongue, hypopharynx, or tracheal rings and the possible reconstructive procedures without causing tension and subsequent necrosis of flaps, particularly in patients previously treated with radiotherapy. The "apron flap" incision guarantees both good access and good cover for the pharyngeal suture line (Fig. 32.1). All structures involved or at risk to be involved by the cancer must be resected including the entire larynx, hypopharynx, preepiglottic space, previous tracheostoma, strap muscles, and ipsilateral lobe of the thyroid gland and paratracheal lymph nodes.

The larynx is mobilized by resecting the pharyngeal and prelaryngeal strap muscles, separating the thyroid gland and ligating its vascular pedicles. The strap muscles are cut at their insertion on the sternum and superiorly at the hyoid bone; the ipsilateral thyroid artery and veins are ligated, the recurrent laryngeal nerve is cut in the tracheoesophageal groove, and the pharyngeal muscles are excised along the posterior edge of the thyroid cartilage. The larynx is now freed on the contralateral side and mobilized up to the level of the hyoid bone (Figs. 32.2 and 32.3).

The trachea is divided at the second ring or below according to the extent of the tumor. The inferior one-half of the remaining tracheal ring is sewn to the skin, and a cuffed tube is placed into the trachea. The entire larynx and part of pharynx that is involved can now be removed from above downward paying attention to dissect in healthy tissue. The base of the tongue is identified and the pharynx entered. The tip of the epiglottis is grasped and pulled anteriorly and inferiorly, and the pharyngeal mucosa together with the

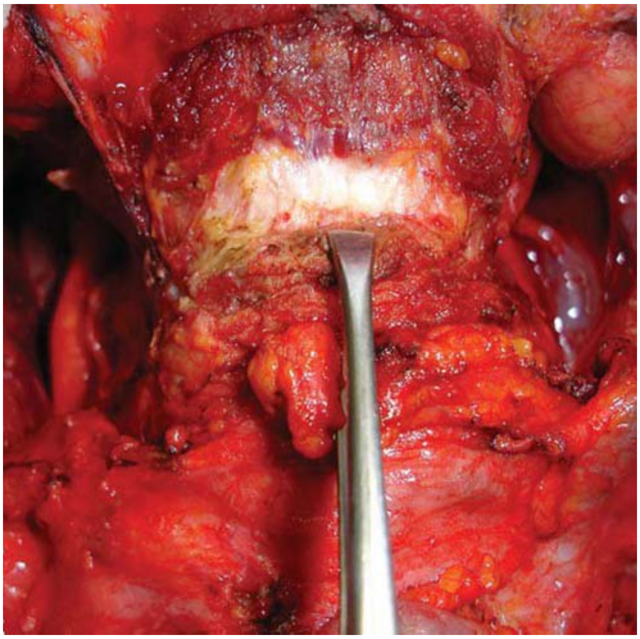

FIGURE 32.2
The strap muscles are resected at their insertion on the superior aspect of the hyoid bone.

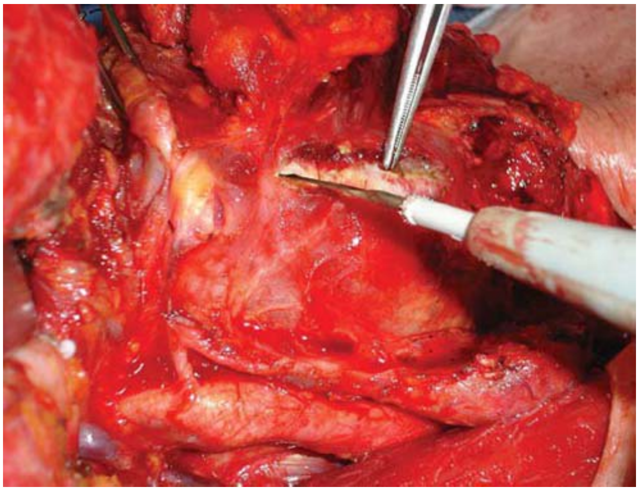

FIGURE 32.3 Resection of the superior and median pharyngeal constrictor muscles.

pharyngeal constrictor muscles is incised on each side of the epiglottis, and of the superior cornu of thyroid cartilage toward the posterior part of the arytenoid cartilage, below the cricoarytenoid joint (Fig. 32.4).

The final step is the repair of the pharynx and the closure of the entire neck (Fig. 32.5). When the entire circumference of the hypopharynx is removed, defects are large; they should be reconstructed with a free flap. When it is possible to preserve a small strip of mucosa of the posterior pharyngeal wall, I usually use a pectoralis major myocutaneous flap that is easy to harvest, commonly bulky, and well vascularized. The flap is rotated almost 180 degrees to reach the neck area. The myocutaneous flap is sutured to the mucosal edges; alternatively the flap may be sutured to the prevertebral fascia that shapes the posterior area of the new hypopharynx. After placement of a salivary stent, the distal ends of the flap are sutured to the base of the tongue and the lateral border to the remaining posterior pharyngeal wall or to the prevertebral fascia and the inferior area is joined to the inferior portion of the pharynx or cervical esophagus.

Another possible choice for reconstruction of the pharynx is the gastric pull-up: this technique is used to reconstruct a defect following a total laryngopharyngoesophagectomy due to an involvement of the esophagus by the pharyngeal cancer. In this situation, a multidisciplinary team must be recruited and a cervical and abdominal approach in order to remove the mobilized esophagus and to mobilize and tubulize the stomach. This tube is transferred superiorly to the cervical region and sutured to the mucosa of the base of tongue and oropharynx.

When the cancer does not involve the esophagus, the defect can be reconstructed using a jejunal free flap that can be prepared endoscopically by a general surgeon and sutured with a microanastomosis to the vessels in the neck.

Two suction drains are placed close to the suture line and one or two more are placed in the laterocervical space (in case of unilateral or bilateral neck dissection); the skin is closed in two layers. The inferior border of the apron flap is sutured to the membranous part of the trachea to complete the pharyngostomy.

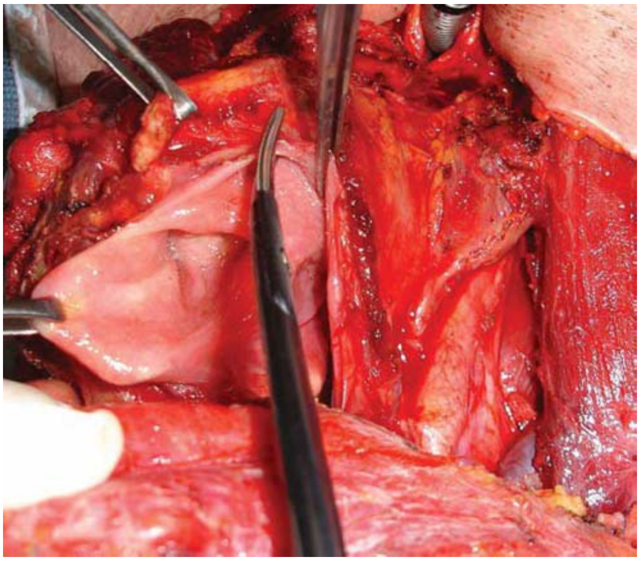

FIGURE 32.4 The pharyngeal mucosa is resected close to the epiglottis folds.

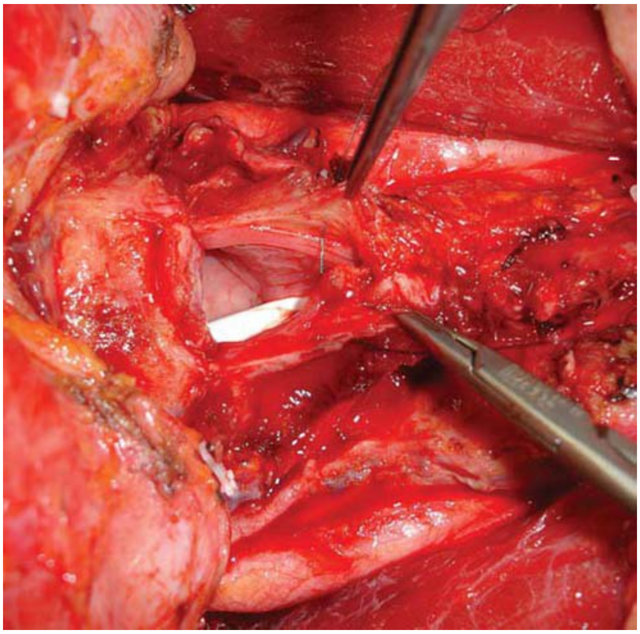

FIGURE 32.5
Closure of the pharyngostomy.

POSTOPERATIVE MANAGEMENT

An antibiotic chemoprophylaxis (amoxicillin–clavulanate, 1.2 g intravenous) is started at the time of the skin incision and administered every 3 hours during surgery and continued three times per day for 72 hours on the ward. A new first-line antibiotic chemoprophylaxis is started if fever develops (>38°C) or in the presence of infections (e.g., pulmonary) or purulent secretions.

Immediate postoperative care includes complete blood count, hematocrit, electrolytes and coagulation study, temperature, body weight, intravenous fluid volume, blood pressure, and if needed, an electrocardiogram, respiration rate, chest radiograph, respiratory therapy, and care of the tracheostoma.

The nasogastric feeding tube intake is started on the first postoperative day. After evaluation of the complete recovery of the suture of the neopharynx with a barium swallow test, generally 7 or 10 days after surgery (in nonirradiated or preirradiated patients, respectively), the feeding tube is removed and oral intake with soft food and fluids is started. The patients are generally discharged 24 to 48 hours after oral intake without complications.

COMPLICATIONS

Complications can be immediate, intermediate, and long term.

Immediate includes postsurgical bleeding with or without subsequent hematoma, airway obstruction due to blood or secretions, or intra- or perioperative mortality due to cardiovascular complications.

Intermediate may be divided into general or local complications. The general complications are those arising from any major head and neck surgery, such as postoperative pneumonia or pulmonary embolism. A subcutaneous infection can appear generally with fever, increasing erythema, or edema of the skin flap, 3 to 5 days after surgery, but the most frequent local complications are wound breakdown, particularly in patients who have been radiated, or neopharyngeal fistula due to dehiscence of the neopharyngeal suture line. The number of pharyngeal fistulas is higher in patients who undergo concomitant radical or bilateral neck dissection, in patients who undergo surgery after radiation failure, and in patients with more advanced cancer. Intercurrent diseases such as diabetes or alcoholism, preoperative long-standing tracheostomy, poor nutritional status, postoperative reduced hemoglobin levels or hemorrhage, wound infections, and timing of postoperative oral feeding are also considered predisposing factors for the development of a pharyngeal fistula. The appearance of a pharyngeal fistula results in a delayed outcome and rarely in rupture of the carotid artery. Pharyngocutaneous fistula when <1 cm in patients who have not been radiated, detected also by the swallowing test, can be managed by local compressive dressing and antibiotic therapy; in patients with a fistula >2 cm, in preirradiated patients and ipsilateral to the dissected neck, I recommend a revision of the wound under general anesthesia and a transposition of suitable flaps and placement of a salivary stent. Partial or complete necrosis of the flap develops in 3% to 10% of patients. In case of complete necrosis, a new flap reconstruction is needed.

Long-term complications are related to stomal or neopharyngoesophagus stenosis. Trachea stomal stenosis usually develops within a year after surgery. The use of a tracheal cannula can prevent stenosis: I suggest that the cannula be kept in place for at least 3 months after primary surgery and 6 months after salvage surgery. Generally, years later after a TL with pre- or adjuvant radiotherapy, patients may develop a pharyngoesophageal stricture or a stenosis: this can have a negative influence not only on swallowing and nutrition but also on tracheoesophageal speech production. In those cases, I suggest esophagoscopy and dilation of the stenosis after ensuring the nononcologic nature of the stenosis.

RESULTS

Positive surgical margins, presence of more than one positive metastatic lymph node, and extracapsular spread of nodal metastases and advanced stages are considered high-risk factors for failure and are associated with a high incidence of locoregional recurrence and poor prognosis. In these cases, adjuvant treatment (radiotherapy or chemoradiotherapy) is indicated.

PEARLS

- The correct indication to an appropriate treatment represents the most important factor for therapeutic success.
- Before starting surgery, knowledge of the local and regional stage of the disease is mandatory to plan a correct surgical approach, including the need for flap reconstruction and avoiding unnecessary neck dissection.
- The location of the cancer and the knowledge of the lymphatic spread, in fact, allow the surgeon in the decision to perform bilateral node dissection, hemi- or total thyroidectomy, and partial esophagectomy.

PITFALLS

- The undertreatment, especially in the case of salvage surgery, compromises oncologic outcome, while overtreatment increases the risk of postoperative complications.
- The use of electrocautery on the pharyngeal mucosa predisposes to wound breakdown, especially in pretreated (irradiated) patients.
- Embarking on laryngopharyngeal resection without firm knowledge of tumor extent, anatomy involved, and the need for reconstructive options to permit effective speech and swallowing dooms the patient to failure.

INSTRUMENTS TO HAVE AVAILABLE

- Cold knife for the skin incision
- Bipolar scissors for the neck dissection
- Monopolar electrocautery for the laryngectomy
- Vessels larger than 3 mm are ligated and the vessels <3 mm are sealed by radiofrequency forceps or monopolar cautery.

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33 OPEN TRACHEOSTOMY

Eugene N. Myers

INTRODUCTION

Tracheostomy is one of the oldest surgical procedures recorded in human history and was born from the omnipresent condition of impending death from airway obstruction. The procedure described in predynastic Egyptian tablets that many interpret as the earliest images of tracheostomy dates from about 3600 BC. The Rig Veda, a Hindu text, gives a clear description of entering the anterior neck and trachea. In the fourth century BC, Alexander the Great was said to have performed a tracheotomy with the tip of his sword on a soldier who was choking. On the other hand, the most glaring omission in the history of our country was the lack of a tracheostomy in the case of George Washington when he had airway obstruction from epiglottitis. He was treated with bleeding rather than tracheostomy and died soon after.

Despite the evolving techniques for management of diseases and trauma, access to the tracheal lumen will remain an imperative to ensure adequate ventilation. The evolution of tracheotomy and intubation through the natural route is a remarkable chronicle of disease, survival, medical and surgical evolution, creative tool making, and scientific discovery. Tracheal cannulation will always be a crucial element in the management of a wide variety of conditions of the upper aerodigestive tract. This rich history should provide surgeons with valuable perspectives on their current strategies for management of the airway.

Tracheostomy may be one of the easiest or most difficult and frustrating of surgical procedures. When the procedure is elective, performed in the operating room on an adult with a slender neck and no airway obstruction, it is usually a simple straightforward procedure associated with few, if any, problems. In contrast, the same procedure on a patient with a short fat neck struggling because of air hunger may be one of the most difficult and frustrating of surgical procedures.

The highest priority before performing a tracheostomy is securing the airway. Endotracheal intubation is the most common way of securing the airway while a more permanent airway is achieved by performing a tracheostomy. The optimal conditions for performing a tracheostomy include having the patient in the operating room with a secure airway, adequate light, suction, proper instruments, and experienced assistants.

HISTORY

The indications for tracheostomy fall into three major categories including alleviation of upper airway obstruction, maintenance of pulmonary toilet, and long-term ventilatory support. The history of upper airway obstruction may be very brief such as in patients with trauma to the neck, foreign body aspiration, and acute infection.

The patient may be seen in the emergency room with airway problems, which require immediate tracheotomy in order to alleviate the obstruction. In the above-mentioned problems, endotracheal intubation may be impossible due to massive bleeding or marked distortion of the airway such as in cervical trauma. Some patients will present with air hunger, dyspnea, and, in the most dire cases, cyanosis. The history in such cases may need to be obtained from the individuals who accompany the patient, such as family or friends, and

occasionally after the fact. In some cases, particularly of trauma such as in an automobile or industrial accident, the patient may not be able to give a history or a history is available only by way of the paramedics who transported the patient from the field.

The history of the patient who requires a tracheostomy for pulmonary toilet varies widely and may range from an individual who has a history of chronic aspiration due to cancer of the head and neck or its treatment to individuals who may have debilitating diseases such as emphysema, chronic obstructive pulmonary disease, acute or chronic pain, or progressive neurologic diseases such as myasthenia gravis and muscular dystrophy.

Perhaps the most frequent need for tracheostomy in modern times is to provide a secure airway in patients who require long-term ventilatory support, such as comatose patients, in patients with chronic lung disease, or in patients who have had more than 7 days of endotracheal intubation. Tracheostomy is performed in order to remove the endotracheal tube to prevent injury to the vocal cords and the subglottic region. Due to the patient's serious condition and the presence of the endotracheal tube, the history of such patients may need to be provided by family or caregivers.

The history in other cases includes elective airway management in conjunction with the head and neck oncologic resection, acute infection such as epiglottitis, anaphylaxis, and patients who require long-term ventilatory support such as transplant patients with congestive heart failure and head trauma.

PHYSICAL EXAMINATION

The most important aspect in evaluating the patient with acute airway obstruction is to identify the etiology of the obstruction so that one can make a decision as to whether an immediate tracheostomy is necessary or endotracheal intubation can be carried out since a safe and successful tracheostomy is much easier to accomplish in a patient with a stable airway.

Evaluation of the patient's acute airway obstruction may be hindered by air hunger, struggling or moving about, and bleeding into the upper airway. Examination of the upper airway should include an estimate of how much of the airway has been obstructed, whether there is a history of cancer of the upper airway, whether the patient is taking anticoagulants, or whether the patient aspirated a foreign body or may have been taking medication that resulted in acute allergic or anaphylactic reactions resulting in acute upper airway obstruction.

It is important to see if the patient with partial airway obstruction can be placed in the supine position for the tracheostomy without completely obstructing the airway. If not, then the tracheostomy should be carried out with the patient in the sitting position. Other important aspects in the physical examination includes the patient's body habitus, for instance, very obese patients present a potential problem in carrying out tracheostomy. The patient with severe kyphosis, tumor involvement of the skin, and burns of the face, neck, and chest also presents a challenge for the surgeon.

Patients who will receive a tracheostomy for pulmonary toilet may already have an endotracheal tube for temporary pulmonary toilette. In these situations, the tracheostomy should be carried out with the endotracheal tube in place. If the patient is ambulatory, the tracheostomy can be carried out under a local anesthetic with intravenous sedation.

Whether to carry out the tracheostomy in the intensive care unit (ICU) setting or in the operating room is a controversial issue. However, we believe that the tracheostomy carried out in the operating room under ideal conditions will give better long-term results and fewer complications and is well worth the extra cost.

INDICATIONS FOR TRACHEOSTOMY

- Airway obstruction such as compression outside the tracheal lumen due to a thyroid mass
- Trauma to the neck causing severe injury to the laryngeal framework, great vessels, or hyoid bone
- Edema of the airway due to trauma, burns, infection, or anaphylaxis
- Abnormality within the tracheal lumen, for example, primary tracheal tumor or subglottic extension of primary cancer of the larynx
- Abnormality within the tracheal wall such as tracheomalacia
- Abnormality of the epiglottis or supraglottis, such as congenital anomalies, stenosis, infection, tumor, or bilateral vocal cord paralysis
- Elective airway management in conjunction with extensive surgery for cancer of the head and neck
- Severe obstructive sleep apnea
- To provide access for adequate pulmonary toilet especially in patients with chronic aspiration, those who are unable to cough effectively due to pain such as with fractured ribs, individuals with generalized weakness, or those who have chronic neurologic problems such as myasthenia gravis, muscular dystrophy, or multiple sclerosis
- Patients requiring long-term ventilatory support, both in the ICU setting and in the chronic care hospital setting

CONTRAINDICATIONS

- Patient refusal
- Patients with severe coagulation disorders
- Recurrent cancer of the upper digestive tract with minimal life expectancy

PREOPERATIVE PLANNING

The highest priority before performing the tracheostomy is securing the airway. It is important to determine the site and type of airway obstruction. When the tracheostomy is performed electively in a patient without airway obstruction, such as with resection of cancer of the head and neck, this is not usually a problem. The procedure in such patients may be done under local or general anesthesia prior to the resection or after the procedure prior to closing the wound. Doing the tracheostomy prior to the resection has the marked benefit of having the endotracheal tube out of the airway to provide better exposure of the tumor.

The patient with air hunger from a compromised airway should have an endotracheal tube inserted to insure that the patient is well ventilated throughout the procedure. The patient who has a large obstructive cancer of the larynx, cervical trauma, or similar type of obstruction or bleeding will not be able to be intubated and will need to have tracheostomy carried out under local anesthesia.

In patients who have partial obstruction such as a foreign body, a radiographic study may be of great help if it does not jeopardize the remaining airway. It is important in preoperative planning to decide how the patient will be positioned and whether they can actually lie in the supine position. Patients who have severe air hunger and cannot tolerate the supine position will need to have a tracheostomy carried out in a sitting position.

As far as possible, tracheostomy should be carried out in the operating room under ideal circumstances requiring the following:

- Securing the airway
- Adequate illumination
- Adequate suction
- Experienced assistants

The tracheostomy may be very simple and straightforward procedure; however, in the absence of a secure airway, illumination, suction, and assistants, the tracheostomy may be one of the most difficult, frustrating, and dangerous of surgical procedures.

SURGICAL TECHNIQUE

The patient is placed on the operating table or other firm surface with a rolled towel or sheet under the shoulders to extend the neck (Fig. 33.1). This brings the trachea more anterior in the neck and exposes more of its length. A small pillow or rubber "doughnut" should be placed under the patient's head to stabilize it during surgery. Some patients with obstruction of the airway cannot tolerate lying supine, and in these patients, the tracheostomy must be performed under local anesthesia with the patient in a sitting or semi-sitting position. In other patients, such as those with cervical osteoarthritis, questionable or documented fractures of the cervical spine, or severe kyphosis, the neck cannot be extended making the procedure even more difficult.

In adults, tracheostomy may be carried out under local or general anesthesia. In patients with a difficult airway, the use of a local anesthetic allows spontaneous respiration until the airway is secured. General anesthesia, if needed, can be induced once the tracheostomy has provided a secure airway. Many patients requiring tracheostomy are at high risk of respiratory distress either because of existing airway obstruction or because of associated medical or surgical problems. When possible, these patients should undergo oral or

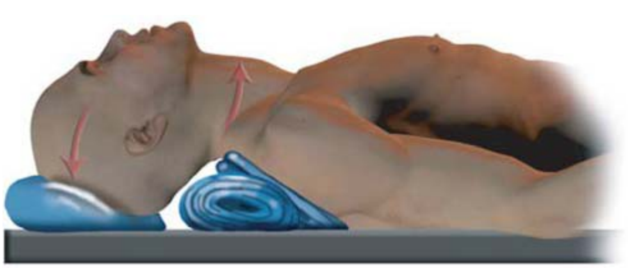

FIGURE 33.1 Positioning of patient for tracheostomy with a rolled blanket under the shoulder to extend the head.

nasal endotracheal intubation prior to tracheostomy to secure the airway and to prevent struggling during the procedure and to be certain that the patient is well oxygenated. Patients from the ICU who are being maintained by mechanical ventilation through an endotracheal tube should undergo a tracheostomy under local anesthesia. The oxygen level should be continuously monitored with a pulse oxygen monitor.

The line of incision should be marked on the skin prior to placing the patient in extension and before the local anesthesia is injected to avoid distortion of the anatomical landmarks. Whenever possible, the incision for the tracheostomy should be incorporated into any incision, which is planned on the neck. When using local anesthesia, Xylocaine 1% with 1:1,000,000 epinephrine should be injected into the skin and subcutaneous tissue where the incision for the tracheostomy has been outlined. Although the anesthetic effect occurs instantly after injection, it takes 5 to 10 minutes for the vasoconstrictive effect of the epinephrine to develop in order to prevent bleeding. In nonemergency situations, the local anesthetic is injected, and while the vasoconstriction is developing, the patient can be prepared and draped for surgery. In patients undergoing tracheostomy under general anesthesia, it is not necessary to inject local anesthesia since hemostasis can be secured with electrocautery. This however is the surgeon's choice.

After the airway has been secured and the patient has been positioned correctly, the face, neck, chest, and shoulder should be sterilized with prep solution and the patient draped to allow easy access to the neck. During awake tracheostomy, I do not drape the face since this allows the surgeon to monitor the patient for pain or air hunger. Patients who have not been intubated may receive oxygen by nasal catheter. This catheter should also be prepared with antiseptic solution. The anesthetist must be notified to stop the flow of oxygen prior to the use of electrocautery in order to prevent an explosion or a fire.

A transverse incision is made in the skin approximately 1 cm above the suprasternal notch, in the triangle (Jackson triangle) bounded by the cricoid cartilage superiorly, and in the medial aspect of the sternocleidomastoid muscles laterally (Fig. 33.2). This incision uniformly produces an acceptable cosmetic appearance. Sharp dissection is carried down through the subcutaneous tissue. The rake side of a pair of sharp Senn retractors is used to retract the superior and inferior skin flaps. Using the blunt side of another pair of Senns, the anterior jugular veins are identified and retracted laterally. The strap muscles are separated in the midline and retracted laterally with the blunt side of the Senn retractor. The isthmus of the thyroid gland is visualized and the anterior wall of the trachea is identified (Fig. 33.3).

The isthmus of the thyroid gland is retracted superiorly with the rake end of a blunt Senn retractor (Fig. 33.4). In most cases, it is not necessary to transect the isthmus of the thyroid. Should transection of the

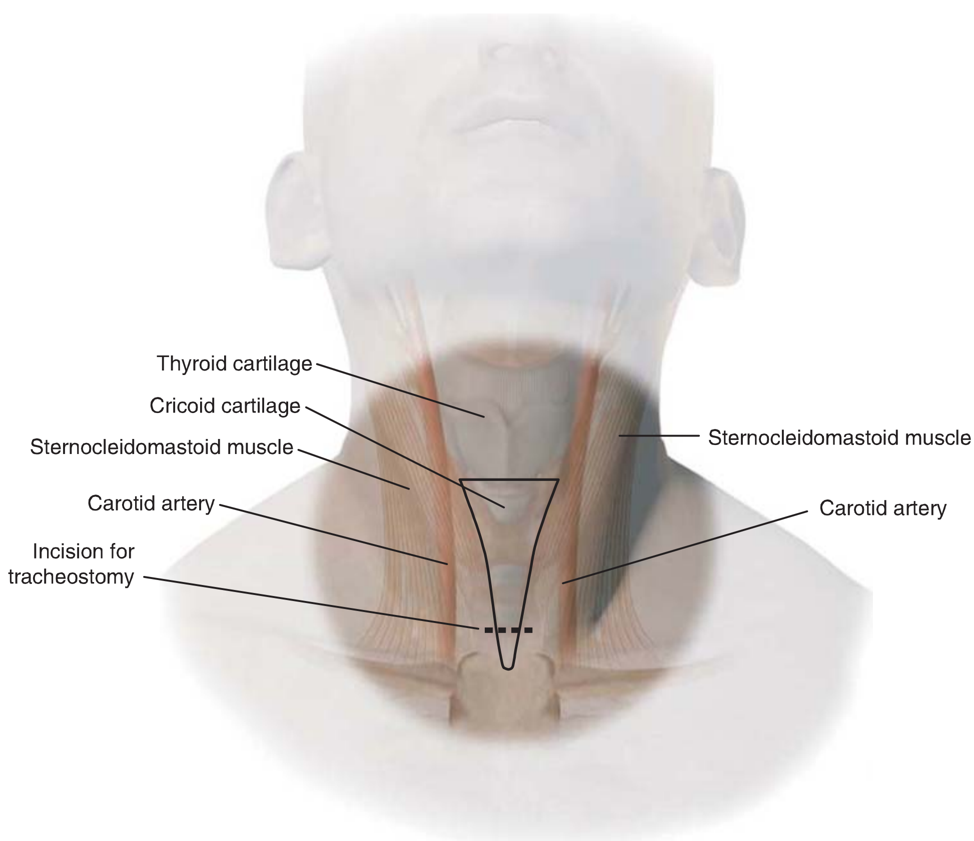

FIGURE 33.2
Jackson triangle with *solid lines* indicating the anterior border of the sternocleidomastoid muscles (SCM) with position of carotid arteries (CA) laterally and the cricoid cartilage (CC) superiorly. Transverse incision shown as *a broken line*.

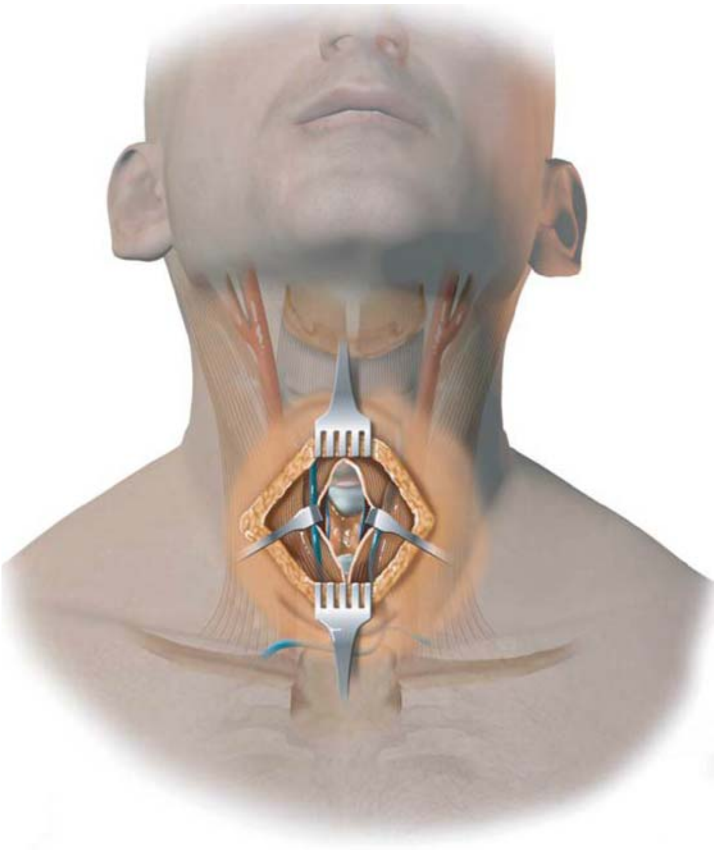

FIGURE 33.3 The trachea and thyroid isthmus are identified; anterior jugular veins, trachea and thyroid isthmus are identified.

isthmus be necessary, it is done most easily by undermining the isthmus and placing right-angle clamps on each side of the isthmus. The isthmus is then transected, and the cut edges of the isthmus are oversewn with silk sutures to prevent bleeding. Some surgeons prefer to transect the isthmus using electrocautery without using sutures. Proper retraction of the strap muscles and the thyroid isthmus will provide excellent exposure of the trachea. If the dissection is kept in the midline, there should be no bleeding.

Once the trachea had been exposed in the awake patient, a small amount of the local anesthesia is infiltrated into the anterior wall of the trachea to eliminate pain. It is not necessary to inject into the tracheal lumen since this only makes the patient cough and does not provide adequate anesthesia of the mucosa. It is important to limit dissection to the anterior wall of the trachea in order to prevent pneumothorax, pneumomediastinum, subcutaneous emphysema, tracheoesophageal fistula, or bleeding.

The cricoid cartilage is palpated to determine the level at which to enter the trachea. In the patient with a cuffed endotracheal tube in place, it is prudent to have the cuff deflated prior to making the incision in the trachea in order to avoid puncturing the cuff. An incision is made in the space between the second and third tracheal rings (Fig. 33.4). Once the incision is made, a tracheal hook is placed so that it engages the tracheal ring superior to the incision from within the trachea. Another transverse incision is then made below the third tracheal ring. In older patients, the tracheal rings are calcified and cannot be cut with a scalpel, so a heavy curved Mayo scissor can be used to cut vertically through the tracheal ring on the side closest to the surgeon. The cut edge of the tracheal ring is then grasped with an Allis clamp and cut through on the far side leaving a window in the trachea (Fig. 33.5). It is important to grasp the cartilage ring firmly to prevent it from falling into or being aspirated into the tracheobronchial tree. If necessary, the stoma may then be enlarged by removing additional cartilage with a Kerrison rongeur. Removal of the anterior aspect of the tracheal ring ensures that the tracheostomy tube is placed in the trachea rather than in a false passage anterior to the trachea. It also provides a comfortable and secure fit of the cannula in the trachea and provides an ample opening for future changes of the tracheostomy cannula.

Traction sutures may be used to facilitate reinsertion of the tracheostomy cannula in the event that it should become dislodged in the immediate postoperative period before a tract has formed. I recommend 2-0 silk sutures on a ligature passer, which is easier to manipulate in the depths of the wound than a curved needle. A tracheal hook is used to mobilize the superior edge of the tracheal ring into the wound, the ligature passer is passed at an angle through the interspace just above the ring superior to the stoma and into the lumen, and care being taken not to penetrate the posterior wall of the trachea. A small curved clamp is used to grasp the suture

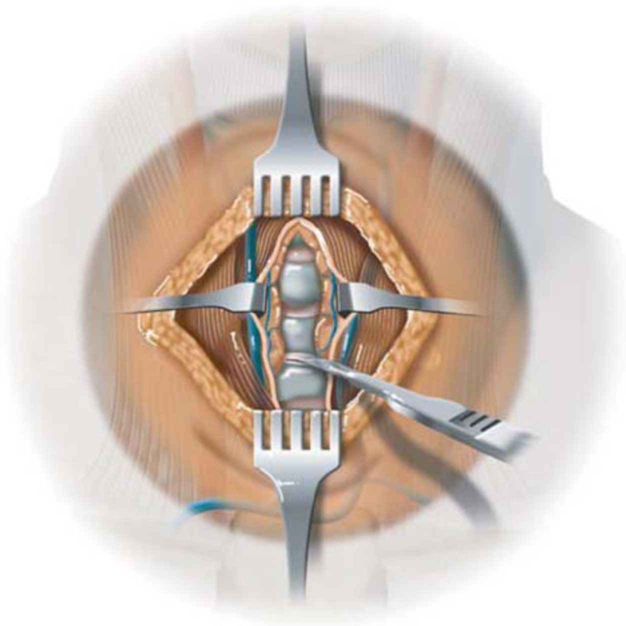

FIGURE 33.4
The trachea is entered through an incision between the second and the third tracheal rings as the thyroid isthmus is retracted superiorly or divided, as required.

while the ligature passer is removed. A similar procedure is carried out through the tracheal ring inferior to the stoma (Fig. 33.6). Once the sutures are placed, traction is applied to both sutures and the sutures are held parallel to the trachea. This exteriorizes the tracheal stoma and retracts the skin edges for additional exposure of the stoma. At this time, either a tracheostomy tube or an endotracheal tube is inserted according to the indications for the tracheostomy.

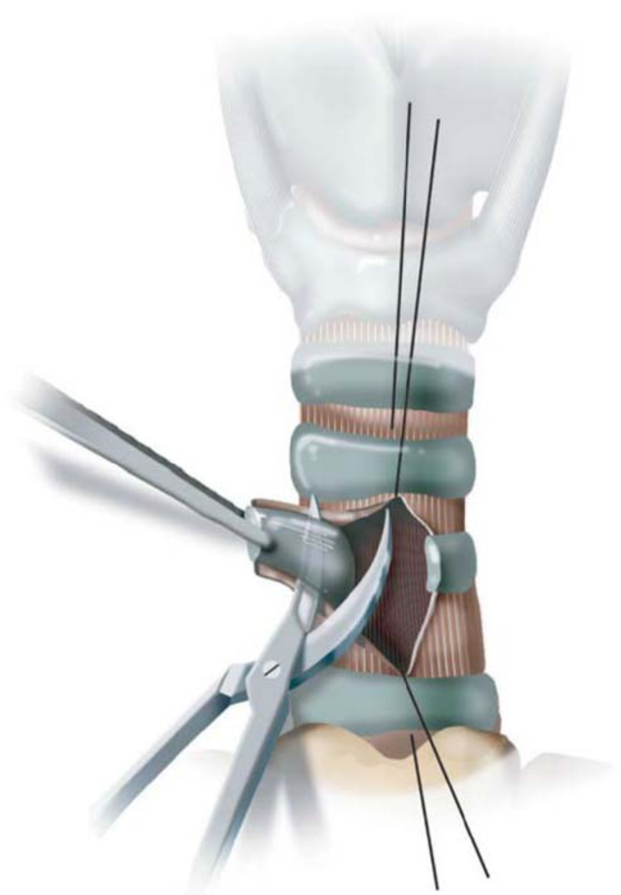

FIGURE 33.5
A portion of the tracheal ring is removed to form a window in the trachea.

FIGURE 33.6 Traction sutures are placed superior and inferior to the stoma in adults.

The traction sutures provide an extra measure of safety in the immediate postoperative period. If the tracheostomy tube is accidentally dislodged, it may be difficult or impossible to replace as a tract from the skin to the trachea has not yet formed. If the dislodged tracheostomy tube is forced blindly into the newly formed stoma, especially in what is usually a panic situation, a false passage between the anterior wall of the trachea and the sternum may be created in which case the patient's airway is severely compromised. In such cases, the patient develops severe subcutaneous emphysema and pneumomediastinum or pneumothorax when ventilation through the tracheostomy tube is attempted. This usually occurs in the nursing unit where sufficient light or proper instruments are not available, particularly in a restless, uncooperative patient with airway obstruction. If the patient has had traction sutures placed, the airway can easily be exteriorized by pulling up on the traction sutures toward the skin and then holding them parallel to the chest. This maneuver pulls the stoma into the wound and retracts the skin edges, thereby reestablishing the airway until such time that the tracheostomy tube or an endotracheal tube can be safely inserted.

Once the traction sutures have been satisfactorily placed, the tracheostomy cannula is inserted into the stoma. This is begun with the cannula at right angles to the trachea; then as the cannula is inserted, it is rotated so that its axis is parallel to that of the trachea (Fig. 33.7). This eliminates the difficulty encountered in trying to pass the cannula over the patient's chest at a difficult angle to the stoma. For ease and accuracy of insertion, an obturator should always be used when the cannula is being inserted. Once the cannula is properly seated in the trachea, the obturator is promptly removed and the inner cannula inserted. If an endotracheal tube or bronchoscope had been used to stabilize the airway, it must be removed from the area of the stoma, but it should not be removed entirely until the cannula is securely in place. A soft suction tube should be inserted through the tracheostomy cannula to suction out blood and secretions and to be reassured that the cannula is in the trachea. The neck plate of the tracheostomy tube has two vertical slots originally designed to accommodate the cloth tape used to hold the tube in place. I use 2-0 silk sutures inserted through these slots to sew the neck plate to the skin (Fig. 33.8). This is a safety feature to prevent accidental dislodgement of the tracheostomy tube in the early postoperative period. An extended length tracheostomy tube should be used in obese patients to reduce the risk of accidental decannulation.

FIGURE 33.7
Insertion of the tracheostomy cannula begins with the tube at a right angle to the patient then rotated into the midline.

In cases in which the tracheostomy is performed preoperatively for postoperative management of the airway, an endotracheal tube is inserted when the tracheostomy is established. At the end of the procedure when the patient is breathing spontaneously, the endotracheal tube is removed and the tracheostomy tube is inserted by bringing the trachea into the wound with the traction sutures. Right-angle retractors are then used to provide adequate exposure, and the tube is inserted accurately and sutured to the skin as described above.

At the time of the initial tube change, which takes place (on average) on the 6th postoperative day, the skin and traction sutures are removed and a Velcro neck strap is used to replace the sutures and to keep the tracheostomy tube in place. The tube change is done by the surgeons. It is mandatory that the tube change is done with adequate light, suction, and assistance. In most hospitals, nonphysicians are not allowed to make the first tracheostomy tube change; nurses do, however, change and clear the inner cannula. In patients undergoing total laryngectomy, the skin sutures are not necessary.

After the tracheostomy is performed, a tract forms around the tube. Granulation tissue develops in the tract and the tract is difficult to keep clean and becomes colonized with bacteria. When a permanent tract or tracheostomy is desired, the surgical technique should be modified somewhat to facilitate early healing and maintenance of hygiene. This is especially important when frequent access to the trachea is necessary, as in patients with permanent laryngeal stenosis, severe chronic obstructive lung disease, sleep apnea, or those who will be permanently ventilator dependent. Permanent epithelialization of the tracheostomy is facilitated when a skin-to-mucosa tract is created at the initial surgery. A number of complex skin flap procedures have been described, but we feel that these are generally unnecessary.

We try to establish a skin-to-mucosa tract by making a horizontal skin incision 1 cm inferior to the cricoid cartilage. The incision is carried down to the level of the strap muscles. Skin flaps are then elevated approximately 2 cm, both superiorly and inferiorly. The subcutaneous adipose tissue is then removed. The amount of

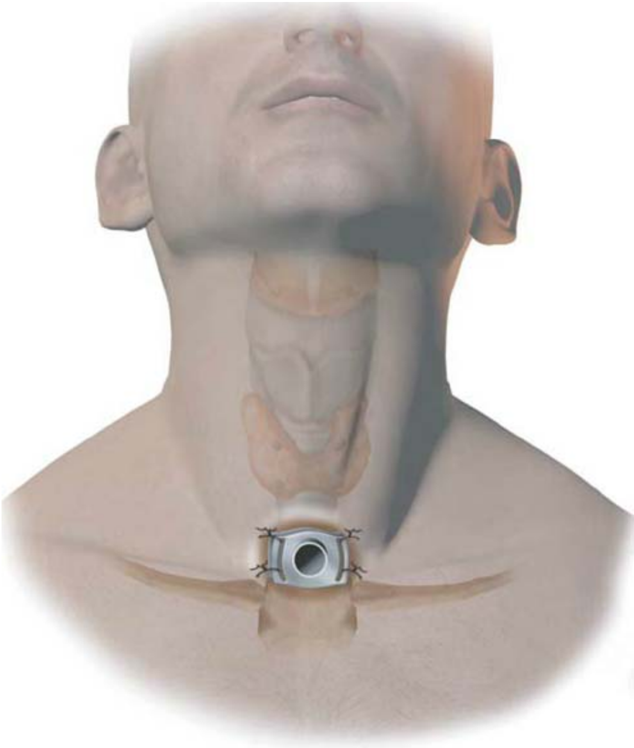

FIGURE 33.8 The neck plate of the tracheostomy tube is sutured to the skin.

soft tissue removed depends in large part on the reason for the permanent tracheostomy and the patient's body habitus. Frequently large amounts of adipose tissue are removed from obese patients who are having a permanent tracheostomy to treat sleep apnea.

The strap muscles are then separated in the midline and retracted laterally. The thyroid isthmus will be encountered and should be divided in the midline and oversewn. The thyroid is then retracted laterally to expose the trachea. An inferiorly based tracheal flap is then made with either the second and third or third and fourth tracheal rings. The tracheal flap is rotated inferiorly and sutured to the skin flap. Redundant skin should be trimmed. The superior skin flap is sutured to the superior aspect of the tracheal wall. No attempt should be made to close the triangular lateral defects, which will heal by secondary intention. The patient is maintained with a tracheostomy tube or button, as the case may indicate. This technique facilitates rapid healing and the establishment of an epithelial tract.

POSTOPERATIVE CARE

The following are critical for postoperative care:

- Frequent suctioning of tracheal secretions through the inner cannula
- Humidified oxygen to prevent drying of the secretions
- Removal and cleaning of the inner cannula. This should be done frequently and helps to avoid accumulation of dried mucous and formation of mucous plugs, which may occlude the inner cannula and provide a potentially life-threatening situation.
- When a cuffed tracheostomy tube is inserted, the cuff should be deflated periodically to avoid pressure on the tracheal mucosa with subsequent necrosis.
- Excessive traction on the tracheostomy tube should be prevented by providing adequate support and stabilization of the tube. This is particularly important with patients who are on ventilatory support and have heavy tubing connecting the tracheostomy tube to the ventilator.
- The tracheostomy tube should be changed in approximately 1 week. At this time, a tract will have formed. The tube change must be carried out by the surgeon with adequate light, suction, and instrument. An assistant should be present during the change of the cannula. The patient's head should be positioned in extension.
- If the patient does not have a sufficient airway, then the tracheostomy tube should be replaced.
- Around the 5th to 6th posttracheostomy day, the cuff should be deflated. The airway should be tested by occluding the cannula and observing that the patient can speak and breathe through the mouth. The tube may be removed and a smaller uncuffed tube can be inserted if necessary.

- Once the patient does well with the smaller uncuffed cannula, the tube may be removed over the next several days. A gauze dressing is taped securely over the stoma, and the patient is instructed to put pressure on the dressing when he wishes to speak or cough.
- Preoperative and predischarge teaching makes postoperative care of the tracheostomy much easier for the patient and the caregiver.

COMPLICATIONS

Intraoperative

- Hemorrhage. Patients with coagulation disorders whether medically based or from ingestion of anticoagulants, aspirin, or nonsteroidal or inflammatory agents may be more prone to excessive intraoperative bleeding. When possible, these problems should be corrected preoperatively. Meticulous hemostasis is no doubt the best way to avoid bleeding during the surgery. Careful attention to the details of the procedure cannot be overemphasized. Section in the midline will prevent most bleeding. The surgeon must be alert to the possibility of an aberrant innominate artery crossing the trachea and always digitally palpate prior to dissection down to the tracheal wall.
- Intraoperative tracheoesophageal fistula may occur when the tracheal wall has been injured inadvertently. The penetration of the posterior wall of the trachea is more likely to occur during an urgent tracheostomy in a struggling patient. When the tracheotomy has been completed, the posterior wall of the trachea should be inspected, and if penetration or laceration has occurred, it should be repaired at this time.
- Pneumothorax. This is usually due to direct puncturing of the pleura by the surgeon and occurs most commonly in children where the apex of the lung protrudes into the inferior aspect of the neck and is vulnerable to injury. Creation of a false passage occurs when the tracheostomy tube is inserted between the anterior wall of the trachea and the posterior aspect of the sternum. This usually occurs when there is a displaced tracheostomy cannula that is inserted without identifying the tracheostomy site. The pneumothorax occurs when attempts are made to oxygenate the patient through the tracheostomy cannula.
- Pneumomediastinum. Pneumomediastinum is usually asymptomatic and is noted on routine chest radiographs. This complication can be avoided by keeping the dissection in the midline. Pneumomediastinum of a severe nature is produced when a false passage has been created.
- Injury to the recurrent laryngeal nerve. This situation is only possible when dissection outside the midline is carried out since the recurrent nerve is a relatively posteriorly and laterally based structure.
- Injury to the cricoid cartilage. This complication usually occurs when the tracheostomy is carried out in an urgent situation and the landmarks are not noted. The cricoid cartilage is usually easily palpated and the tracheostomy can be carried out in the third or fourth tracheal ring. When the cricoid is injured, there is a potential for development of cricoid chondritis and subglottic stenosis.
- Cardiopulmonary arrest. This complication occasionally occurs in patients who have had chronic air hunger and an elevated CO_2 level. When there is sudden relief of chronic upper airway obstruction with the tracheostomy, this may result in congestive heart failure due to extravasation and to fluid into the alveoli in response to reduction of obstruction-induced expiratory pressure. Chronic hypoxia drives the respiratory centers in the brain so when oxygen enters the trachea, CO_2 no longer drives the respiratory center and respiratory arrest may occur. The anesthesia team should be alerted to these possibilities in the event that cardiopulmonary resuscitation is necessary.
- Fire. Fire occurring during tracheostomy is rare and may be a catastrophic event. This usually occurs in situations where electrocautery is being used in the presence of high concentration of oxygen such as would occur in tracheostomy done under local anesthesia. The anesthesiologist should be alerted before the electrocautery is being used so that the oxygen supply may be discontinued until the use of electrocautery is finished.

Immediate Postoperative Period

- Postoperative bleeding. If there is significant bleeding, the patient should be returned to the operating room, the wound explored, and hemostasis achieved. Packing an actively bleeding tracheostomy site is contraindicated because of the potential for subcutaneous emphysema. The best way to prevent postoperative hemorrhage is meticulous intraoperative hemostasis.
- Wound infection. Wound infection in tracheostomy is quite rate. However, the tracheal wound is usually colonized within the first 48 hours by a mixed variety of bacteria. Actual wound infection with cellulitis requires meticulous hygiene with suctioning, cleansing, dressings, and tube changes when necessary to remove crusts and necrotic debris, therefore reducing the load of bacteria. True infection is rare and should be treated with appropriate antibiotics.
- Tube obstruction. This is usually caused by the evolution of the so-called mucous plug, which forms on the distal tip of the inner cannula dries and occludes the cannula. Frequent suction of secretions and frequent

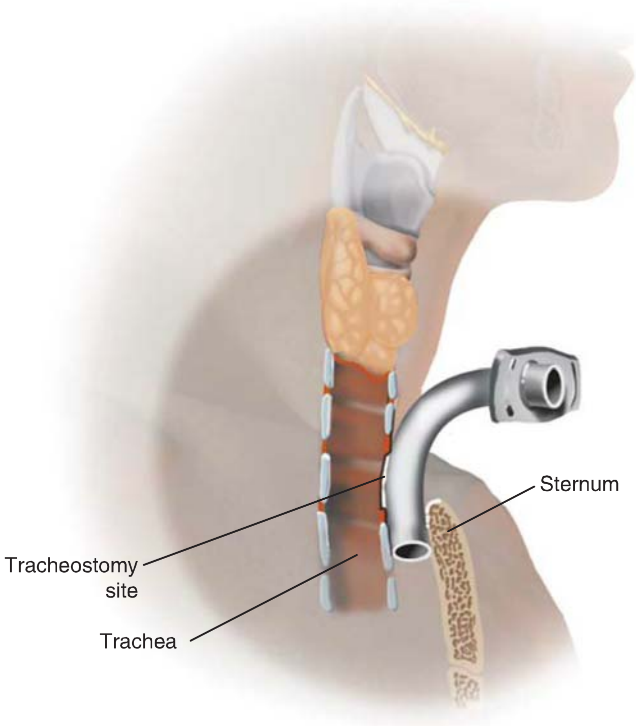

FIGURE 33.9 Sagittal section through the neck and chest of a cadaver, demonstrating a false passage created by the tracheostomy tube mistakenly inserted between the sternum and the trachea.

cleaning of the inner cannula will usually prevent this problem. The treatment is immediate in the patient demonstrating air hunger, the inner cannula should be immediately removed and cleaned and the trachea suctioned, and this is usually adequate treatment for this problem.

- Displaced tracheostomy tube with false passage (Fig. 33.9). This may occur in the first few days postsurgery before a tract has formed. The reinsertion of a displaced tracheostomy tube can also be facilitated by the use of traction sutures. The rapid reinsertion of the cannula without adequate exposure and illumination will result in replacing the tracheostomy tube between the sternum and the trachea, causing what may be fatal loss of the airway. Bagging the patient through the misplaced tracheostomy cannula will cause subcutaneous emphysema, pneumomediastinum, and possibly pneumothorax. This may be prevented by sewing the neck plate of the tracheostomy tube to the surrounding skin.

Late Complications

- Granulation tissue formation. The clinical importance for formation of granulation tissue lies in its tendency to bleed, complicate tracheostomy tube changes, and delay attempts at decannulation and completion of the tracheostomy tube with potentially catastrophic results. This usually occurs in children. The discovery of this granulation tissue usually requires that the patient be returned to the operating room for removal of this tissue. Regular changing of the tracheostomy tube on the schedule of every 2 to 3 weeks has been shown to dramatically reduce the incidence of granulation tissue.
- Tracheoesophageal fistula. Late development of tracheoesophageal fistula is rare and may result from an overinflated or improperly fitted cuff. It is also possible that the posterior wall of the trachea was unwilling penetrated during surgery or secondary infection causing the tracheoesophageal fistula.
- Tracheoinnominate fistula with hemorrhage. This complication usually occurs within the first 3 weeks after tracheostomy and may be fatal. There are several factors, which predispose to this complication such as placing the tracheostomy tube too far inferior in the neck, below the third tracheal ring where the inferior concave surface of the cannula may ride over the innominate artery, an aberrant course of the innominate artery such as one that crosses the trachea at an abnormally high level, using an excessively long or curved tube, the tip of which may erode the trachea and the artery and pressure on the tracheal wall by the cuff. Ruptured innominate artery is usually heralded by a “sentinel bleed,” which may be stopped spontaneously and then be followed at a later time by a catastrophic bleeding. When the sign is recognized, the cuff and tracheostomy tube should be overinflated and the patient taken to the operating room.

A recent report described a tracheoinnominate artery fistula following tracheostomy that was treated successfully by endovascular embolization with coils of the innominate artery.

- Tracheocutaneous fistula. This is usually a sequela of long-term tracheostomy and is usually associated with an unsightly depressed tracheostomy scar. The formation of this fistula is predicated on squamous epithelium migrating from the skin into the trachea forming an epithelial interface with the mucosa of the trachea, thereby creating a true fistula that cannot close spontaneously. Predisposing factors in this situation include the prolonged presence of indwelling cannula, infection, and wasting of subcutaneous tissues in patients who are malnourished.
- Depressed scar. Tracheocutaneous fistula and the depressed tracheostomy scar should be treated at the same time by incising and undermining the skin adjacent to the fistula and inverting the skin so that it forms an inner epithelial surface of the anterior wall of the trachea. The strap muscles are then released from the scar tissue, which holds them laterally and closes the second layer, and then the skin closed with interrupted sutures.
- Tracheal stenosis. Tracheal stenosis is preventable and has been demonstrated by the trend by both endotracheal tubes and tracheostomy tubes to use only high-volume low-pressure cuffs. This has essentially eliminated this complication; however, when it occurs, it requires excision of the stenotic segment and a primary anastomosis.

RESULTS

The result of a tracheostomy properly done under ideal circumstances should be the successful placement of an artificial airway. Securing the airway prior to tracheotomy and having adequate light, suction, proper instruments, and assistants will optimize the outcome. Unfortunately the need for an artificial airway in less than ideal circumstances is fraught with danger and often done in time of panic on a patient with severe air hunger who is struggling to breathe and is uncooperative. This often leads to complications and an undesirable outcome. In modern medicine, even on the battlefield, endotracheal intubation has been most beneficial in securing the airway and providing the opportunity to perform the tracheostomy under circumstances, which will produce good results.

PEARLS

- The airway must be secured prior to performing a tracheostomy.
- Proper light, suction, instruments, and assistant in the operating room are required for a safe outcome.
- The transverse incision for the tracheostomy should be marked on the skin prior to placing the patient's head in extension to insure that the scar will not end up on the sternum.
- Traction sutures are placed in the trachea to allow the stoma to be exteriorized and the airway secured in case of accidental decannulation in the early postoperative period.
- Endotracheal intubation may not be possible in patients with upper airway obstruction from tumor, foreign body, trauma, or bleeding and will require tracheostomy under local anesthesia.

PITFALLS

- A tracheostomy carried out without a secure airway in a patient with air hunger is unsafe and may result in complications or death.
- The use of a vertical incision usually results in an unsightly scar.
- A tracheostomy carried out through the first or second tracheal ring may result in chondritis of the cricoid cartilage and subglottic stenosis.
- If traction sutures are not used to facilitate the insertion of a displaced tracheostomy tube in the early postoperative period, a false passage may be formed leading to airway obstruction and death. Care must be taken to label upper and lowering sutures to avoid crisscrossing them inadvertently.
- Inadequate cleansing of the inner cannula may lead to mucus plug causing occlusion of the cannula with loss of the airway.

INSTRUMENTS TO HAVE AVAILABLE

- Bright light
- Scalpel with no. 15 blade
- Forceps
- Suction
- Sharp and blunt Senn retractors
- Tracheal hook
- Ligature passer with no. 0 silk sutures
- Needle holder

SUGGESTED READING

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34 PERCUTANEOUS TRACHEOSTOMY

Karen M. Kost

INTRODUCTION

Tracheostomy has a long and colorful history. The first reference to the procedure can be found in the sacred book of Hindu medicine, the Rig Veda, dated to approximately 2000 BC. There are many interesting early references to tracheostomy being performed as a lifesaving procedure in both animals and humans. One of the first animal descriptions involves a farmer inserting a hollow reed in the neck of one of his sheep in an effort to save the animal from upper airway obstruction. Alexander the Great is reported to have performed a tracheostomy in the fourth century BC when he "punctured the trachea of a soldier with the point of his sword when he saw a man choking from a bone lodged in his throat." In the early 1600s, Nicholas Habicot of Paris described a successful tracheostomy in a 14-year-old boy who developed upper airway obstruction following an attempt at swallowing a bag of gold coins he had stolen.

For each of these success stories, however, there were many descriptions of tracheostomies associated with high morbidity and mortality rates. Fabricius ab Aquapendente aptly wrote: "The terrified surgeons of our times have not dared to exercise this surgery and I also have never performed it. Even the mention of this operation terrifies the surgeons; hence it is called the scandal of surgery." In 1799, when Dr. Elisha Dick recommended that a tracheostomy be performed for a high-profile patient in airway distress, two colleagues vocally opposed him, and on December 14, 1799, President George Washington died of an acute upper airway obstruction. It was to be the work of Armand Trousseau and later Chevalier Jackson that would successfully bring tracheostomy into the realm of the surgeon's armamentarium. Jackson standardized the technique and indications for the procedure and showed that with attention to a few key technical details, the morbidity and mortality could be dramatically reduced to acceptable levels. As tracheostomy became widely accepted as a useful surgical tool, indications for its use gradually expanded to include upper airway obstruction from croup and diphtheria, trauma, tuberculosis, and syphilis. It was even briefly used as a means of securing the airway during the administration of general anesthesia in the early 20th century.

The first descriptions of percutaneous tracheostomy date back to the 1950s following Seldinger's report of needle replacement over a guidewire for arterial catheterization. The first attempt at percutaneous tracheostomy was reported in 1955 by Sheldon as a means of providing rapid airway access in emergency situations. The technique never gained popularity, however, and the single publication on the procedure reports a case in which the trachea was perforated with the device. Over the next several years and indeed decades, several other percutaneous techniques with various modifications were introduced, but almost all were quickly abandoned because of high complication rates.

Interest in the area persisted, however, and in 1985 when Ciaglia described a bedside percutaneous dilatational tracheostomy technique, the procedure was rapidly adopted in many intensive care units (ICUs), principally by critical care physicians and anesthesiologists. The technique is based on progressive dilatation of an initial tracheal puncture and, as originally described, is performed blindly. An early publication in the otolaryngology literature reported several instances of severe morbidity with the procedure including creation of a false passage, pneumothorax, pneumomediastinum, and even one death. All of these complications were the result of poor patient selection and the blind aspect of the technique. The addition of endoscopic guidance in the early

1990s addressed the blind aspect of the procedure and added significantly to its safety. Several publications of percutaneous dilatational tracheostomy in the last 20 years have shown that with continuous endoscopic guidance and attention to technical detail, percutaneous dilatational tracheostomy is as safe as traditional open surgical tracheostomy in the operating room with similar or lower complication rates.

HISTORY

Critically ill patients often suffer from multisystem disease and require extremely complex care. Tracheostomy is a frequently performed procedure in intubated ICU patients and not surprisingly is associated with a higher risk in this particular subset. Well over half of currently performed tracheostomies are on critically ill patients requiring prolonged mechanical ventilation. Other indications include pulmonary toilet, sleep apnea, chronic lung disease, and conditions requiring home mechanical ventilation. The decision to proceed with a tracheostomy should be based on a thorough assessment of the patient in conjunction with the treating team of the ICU. Several factors may influence the decision to perform the procedure, and these include the facilities at the particular institution, the skills of the personnel, and the particular features of the patient's airway and respiratory physiology as well as the patient's prognosis.

PHYSICAL EXAMINATION

The importance of a comprehensive preoperative patient assessment with particular attention to the examination of the neck cannot be overemphasized. Examination of the neck is very helpful in determining whether a patient is a candidate for endoscopic percutaneous dilatational tracheostomy and will help to avoid any unpleasant surprises during the procedure. Intubated patients in the ICU are often first observed in bed with their head flexed and turned to the side. It is virtually impossible to appropriately examine the neck in this position. It is well worth investing the effort to properly position the patient with the head extended as would be done for open tracheostomy. In very agitated patients, it may sometimes be necessary to administer a small amount of sedation in order to be able to do this. Once the patient is properly positioned, the first step is to palpate the critical landmarks of the neck, which include the cricoid cartilage and sternal notch. The cricoid may lie low in the neck, but with careful palpation, it can usually be identified. The presence of a midline neck mass, a high innominate artery, and a scarred fibrotic neck such as is the case in patients with previous surgery or radiotherapy to the area should all raise red flags. In these instances, percutaneous dilatational tracheostomy may not be appropriate and an open surgical technique in the operating room is likely to be safer. Patients with anatomical deformities such as cervical osteoarthritis and kyphoscoliosis where the neck cannot be extended and the cricoid cartilage is not palpable are not suitable candidates for endoscopic percutaneous dilatational tracheostomy. Obese patients with thick pretracheal soft tissues are at increased risk of accidental decannulation owing to the short proximal length of "standard" tracheostomy tubes. In these patients, placement of a proximally extended tracheostomy tube should be routine.

INDICATIONS

Endoscopic percutaneous tracheostomy should only be considered in adult intubated ICU patients. Since well over half of all of tracheostomies are performed on this patient subset, endoscopic percutaneous tracheostomy is an attractive option for the following reasons: the procedure is well suited for the bedside, the required instruments are simple, and only ambient light is required. This obviates the need for transporting a full instrument kit, headlight, and possible cautery unit, all of which would be required for a standard open bedside procedure.

CONTRAINDICATIONS

Appropriate patient selection is key in reducing complications of endoscopic percutaneous tracheostomy. Contraindications include the following (Table 34.1):

1. Unprotected airway—Attempting endoscopic percutaneous tracheostomy on any patient with an unprotected airway is an invitation to disaster and indeed accounts for some of the early reports of morbidity and mortality. The procedure requires an airway that is secured with an endotracheal tube (ETT) or laryngeal mask airway; a bronchoscope can be passed through either of these for direct endoscopic visualization of the entire procedure.
2. Children—The anatomy of the pediatric airway differs significantly from that of the adult. The trachea is much smaller and more pliable with the carotid arteries in very close proximity. It is therefore difficult to maintain adequate ventilation through a necessarily small ETT that is largely occupied by a bronchoscope. Furthermore, the airway is extremely collapsible, and attempted dilatation is likely to result in anterior/posterior collapse with possible damage to the posterior wall. For these reasons, percutaneous

TABLE 34.1 Contraindications to Percutaneous Tracheostomy

- Unprotected airway
- Children
- Inability to palpate the cricoid cartilage
- High innominate artery
- Midline neck mass
- PEEP requirements >15
- Coagulopathy that cannot be corrected to an INR <1.5 (relative)

dilatational tracheostomy should never be attempted in children. Eligibility for percutaneous dilatational tracheostomy is not so much a function of age but more of physical maturity.

3. Inability to palpate the cricoid cartilage—The cricoid cartilage and sternal notch are key anatomical landmarks, which must be clearly palpable prior to considering endoscopic percutaneous dilatational tracheostomy. Palpating the cricoid cartilage in obese patients requires extra effort. This means placing the head in maximum extension and sometimes requires pulling the skin up over the neck with the left hand to allow the right hand to palpate the cricoid cartilage clearly. Patients with severe anatomic abnormalities such as kyphoscoliosis are clearly unsuitable for percutaneous dilatational tracheostomy.
4. High innominate artery—Careful preoperative examination of the patient allows for an easy identification of a high innominate artery. Resting the index and third finger just above the sternal notch reveals a strong pulsation immediately below. It is important to distinguish a high innominate artery from a transmitted pulsation from the chest.
5. Midline neck mass—A midline neck mass lying over the inferior aspect of the cricoid and the first three tracheal rings is a contraindication to percutaneous dilatational tracheostomy.
6. High positive end-expiratory pressure (PEEP)—Patients who require a very high PEEP of fifteen (15) or more are at risk for complications such as subcutaneous emphysema and pneumothorax. As a result, endoscopic percutaneous dilatational tracheostomy is unsuitable in this group.
7. Coagulopathy—A large number of patients in the ICU have some sort of coagulopathy at the time of consultation for tracheostomy. These abnormalities should be corrected as much as is medically possible preoperatively. Ideally, the number of functioning platelets should be >50,000, and the International Normalized Ratio (INR) should be corrected to a value of <1.5. This being said, many patients are on both aspirin and clopidogrel bisulphate (Plavix) and are unable to stop one or both of these agents for medical reasons. Although the risk of perioperative bleeding is increased in these cases, endoscopic percutaneous dilatational tracheostomy may still be performed and indeed may be the preferred option because of the reduced dissection and risk of bleeding. Ideally, patients on warfarin should stop the drug 5 days prior to tracheostomy or receive fresh frozen plasma. Again, achieving these goals may not be possible or realistic, and in a patient with a persistent low level coagulopathy, endoscopic percutaneous dilatational tracheostomy is preferred to open surgical tracheostomy because of the reduced dissection and incidence of bleeding.

It has been said in the literature that obese patients or those having had a previous tracheostomy are unsuitable candidates for endoscopic percutaneous tracheostomy. Both of these statements are incorrect. Patients having had a previous tracheostomy can certainly have an endoscopic percutaneous dilatational tracheostomy if they have no other contraindications. A small incision should be placed in the previous scar, and the key is carrying the incision down through the scar tissue. The site of the previous tracheostomy can often be identified endoscopically by a small irregularity in the anterior tracheal wall, and this site may be chosen for entry into the trachea. Obese patients are at higher risk of complications whether they undergo endoscopic percutaneous dilatational tracheostomy or open surgical tracheostomy in the operating room. There is no evidence to suggest that obese patients undergoing percutaneous dilatational tracheostomy in the ICU are at an even higher risk of complications. Because of the increased pretracheal soft tissue thickness in this population, it is extremely important to use a proximally extended tracheostomy tube in order to reduce the risk of accidental decannulation. It has been shown that pretracheal soft tissue thickness (Table 34.2) can be reliably predicted within 4 mm in obese patients as a function of neck and arm circumference. Using Table 34.2, it can be seen that a patient with a neck circumference of 55 cm and an arm circumference of 45 cm would have a pretracheal soft tissue thickness of 2.8 cm. A proximally extended tracheostomy tube would be required in this patient since “standard” tubes have too short a proximal length.

PREOPERATIVE PLANNING

As with any surgical procedure, the patient’s comorbidities should be optimized prior to percutaneous dilatational tracheostomy. Preoperative testing is minimal and includes a recent chest radiograph as well as serum determination of hemoglobin, prothrombin time, partial thromboplastin time, INR, and platelets. Because of the minimal bleeding associated with the procedure, cross-matching is not necessary even in the presence of low hemoglobin levels. A fully equipped intubation cart should be available in the event of accidental extubation

TABLE 34.2 Predicted Neck Thickness in Centimeters (cm) as a Function of Neck Circumference (NC in cm) and Arm Circumference (cm)

Arm Circ \ NC Supine	30	35	40	45	50	55	60
20	0.5	0.8	1.1	1.4	1.7	2.1	2.4
25	0.6	0.9	1.3	1.6	1.9	2.2	2.5
30	0.8	1.1	1.4	1.7	2.0	2.4	2.7
35	0.9	1.2	1.6	1.9	2.2	2.5	2.8
40	1.1	1.4	1.7	2.0	2.3	2.7	3.0
45	1.2	1.5	1.9	2.2	2.5	2.8	3.1
50	1.4	1.7	2.0	2.3	2.6	3.0	3.3
55	1.5	1.8	2.2	2.5	2.8	3.1	3.4
60	1.7	2.0	2.3	2.6	2.9	3.3	3.6

during the procedure. Obese patients or those with a short, thick neck and excessive subcutaneous tissues are at particular risk for accidental decannulation. This potential problem can be anticipated and avoided by using a proximally extended tracheostomy tube.

SURGICAL TECHNIQUE

The Bedside Team

Four people are needed for bedside endoscopic percutaneous therapy (PDT), each with a clearly defined role. (1) The surgeon stands at the patient's right. (2) The endoscopist stands at, or close to the head of, the bed and is charged with providing a good view of the intratracheal portion of the procedure, adjusting the position of the ETT, and making sure the airway is protected by securely holding the ETT. Any physician with endoscopic skills may fulfill this role, including a resident, respirologist, anesthetist, or critical care physician. (3) The respiratory therapist at the patient's left is responsible for adjusting ventilator settings. (4) A nurse is required to administer medications during the procedure. The positions of the surgeon and respiratory therapist are reversed for left-handed surgeons.

Anesthesia

The type of anesthesia delivered depends to a great extent on the institution, and the personnel involved. The presence of an anesthetist is optional and again depends on hospital policy. The goal is for the patient to be comfortable. Options include the equivalent of general anesthesia at the bedside or local anesthesia with intravenous (IV) sedation. I typically use the latter, with a combination of midazolam, propofol, and fentanyl. Immediately preceding the procedure, 2 to 3 mg of midazolam is given IV, and 1 to 2 mL of topical lidocaine is sprayed into the ETT to decrease coughing. The incision site is generously injected with lidocaine containing 1:100,000 epinephrine. A bolus of propofol is then given IV based on the patient's weight, followed by a continuous infusion which is titrated according to degree of sedation and vital signs. Fentanyl is given in measured doses for pain throughout the procedure. Tracheostomy is a highly stimulating procedure, and once the tracheostomy tube is in place, the stimulation stops abruptly. It is important to stop the propofol immediately at the end of the procedure to avoid a rapid drop in blood pressure.

Technique

Prior to beginning the procedure, the surgeon should optimally position the patient, prepare the medications, place the instruments, check the bronchoscope, and "troubleshoot" any potential problems in advance with the team. This effort translates into a quick and smooth procedure and reduces the chance of complications.

Although several techniques for performing percutaneous tracheostomy have been developed, the most commonly used in North America is the endoscopic percutaneous dilatational technique. Currently, there are a number of similar, commercially available kits. Periodically, modifications are introduced in an effort to further simplify/streamline an already simple procedure. The different kits have subtle differences, but the common

FIGURE 34.1 The instruments are placed on an instrument stand over the patient's bed in the order in which they are to be used. Above, from left to right: skin preparation solution, gauze, suture scissors, forceps, needle driver, 2-0 or 3-0 silk for suturing the tracheostomy tube to the skin, sterile saline for activating the hydrophilic coating on the single dilator. Below, from left to right: gauze for skin preparation, 10-mL syringe with 2% lidocaine with 1:100,000 epinephrine, #15 blade scalpel, mosquito, 5-mL syringe with sheathed introducer needle, J-wire, introducer dilator in center, single dilator preassembled over guiding catheter with ridge, no. 6 tracheostomy tube with prefitted 26-French Obturator dilator.

denominator in all of them is dilatation of an initial tracheal puncture with a single, sharply tapered dilator. More recently, a kit with an inflatable balloon, instead of the single dilator, was introduced to dilate the tracheal puncture: purported advantages include evenly distributed radial pressure and dilatation of the trachea, thus avoiding the depression of the anterosuperior tracheal wall seen with the single dilator. Because there is no evidence that any one kit is superior, the choice becomes a matter of personal preference.

One of the most thoroughly evaluated kits in North America is the Ciaglia Blue Rhino percutaneous introducer kit (Cook Critical Care Inc., Bloomington, IN). The basic kit contains the following: a 15 blade scalpel, a 5-mL syringe, an introducer needle, a J-wire guide, an introducer dilator, a white guiding catheter, a sharply tapered single blue dilator with a hydrophilic coating, as well as 26-French and 28-French loading dilators.

Other required instruments include a curved hemostat, straight scissors, a needle driver, forceps, nonresorbable sutures, water-based lubricant, and sterile saline to activate the hydrophilic coating of the single dilator, two 10-mL syringes, and an appropriately sized tracheostomy tube.

The instruments are placed on an instrument stand over the patient's bed in the order in which they are to be used (Fig. 34.1). The preselected tracheostomy tube is fitted over the loading dilator: A no. 6 Shiley tracheostomy tube is fitted over the 26-French loading dilator, while a no. 8 Shiley tracheostomy tube is fitted over the 28-French loading dilator. Shiley "Per-Fit" tracheostomy tubes are commercially available and are specially tapered to permit easier insertion. The single dilator comes preassembled with the tip resting on the ridge of the guiding catheter. An appropriately sized bronchoscope with a suction is chosen to fit within the ET tube while still allowing adequate ventilation (Fig. 34.2). A pediatric bronchoscope works best for ETT <7.5 mm. Almost any bronchoscope can be used in patients ventilated through a laryngeal mask airway. When available, video monitors can be connected to the bronchoscope, allowing the entire team to see the intratracheal portion of the procedure.

With the instruments prepared, appropriate sedation is administered, the patient is thoroughly suctioned, and ventilator settings are adjusted to deliver 100% O_2. Vital signs including heart rate, blood pressure, and oxygen saturation are monitored continuously throughout the procedure (Video 34.1). The patient is positioned as for conventional tracheostomy with the neck extended provided there is no contraindication (e.g., cervical spine fracture). Important anatomical landmarks including the thyroid and cricoid cartilages and sternal notch are palpated. The patient's neck and upper chest are then prepped and draped in a standard fashion, and the incision site is infiltrated with 2% lidocaine with 1:100,000 epinephrine.

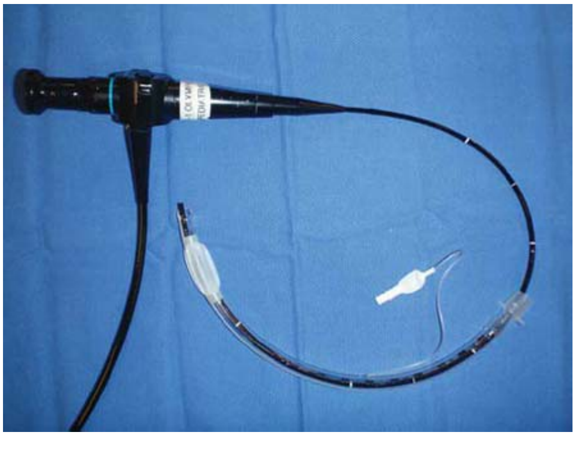

FIGURE 34.2 Bronchoscope fitted within ETT, while allowing for adequate ventilation.

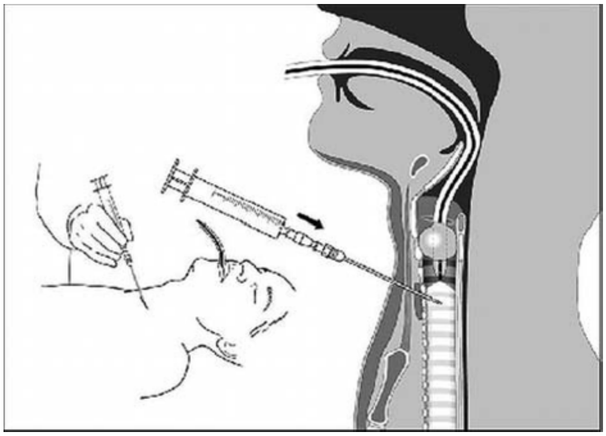

FIGURE 34.3
A 1.5- to 2-cm incision has been made, and the subcutaneous tissues, platysma, and strap muscles have been spread. The tracheal wall is palpated and a sheathed introducer needle is positioned between the first and second or second and third tracheal rings. (From Myers EN. *Operative Otolaryngology: Head and Neck Surgery*. Philadelphia, PA: Saunders/Elsevier, 2008, with permission.)

A small 1.5- to 2-cm horizontal incision is made at the level of the first and second tracheal rings. A curved mosquito or hemostat is used to spread the subcutaneous adipose tissue, platysma, and strap muscles, allowing for easy palpation of the anterior tracheal wall. At this point, 1 to 2 mL of 4% lidocaine is instilled into the ETT to decrease coughing, and ties and tapes are loosened. The bronchoscope is then inserted through an adapter to the end of the ETT, which is securely held at all times. As a unit, the bronchoscope and ETT are withdrawn together to the level where the wound is transilluminated and the anterior tracheal wall can be seen being depressed by a hemostat. With the bronchoscope and ETT in place, a no. 14 or no. 16 Teflon catheter introducer needle is positioned between the first and second, or second and third tracheal rings, and adjusted so that it enters the trachea between eleven and one o'clock (Fig. 34.3). The posterior wall is avoided. The needle is removed, and a J-tipped guidewire is threaded into the trachea through the remaining sheath (Fig. 34.4). The sheath is replaced by a 14-French introducer dilator, which is also removed, leaving only the guidewire in place (Fig. 34.5). At this point, there is often some leakage of air through the wound, which can be finger occluded if necessary. The single dilator/guiding catheter unit is dipped in saline to activate the hydrophilic coating, held like a pen as it is threaded over the guidewire between the markings, and advanced into the trachea in an arc (Fig. 34.6). Sufficient dilatation is achieved when the thick black mark of the dilator is seen endoscopically. This slightly overdilates the tracheal aperture and ultimately facilitates insertion of the tracheostomy tube. The dilator is left in place for 10 to 20 seconds, while the tracheostomy tube, prefitted with the appropriate loading dilator, is accessed. The single dilator is removed, and the preloaded tracheostomy tube is advanced over the guidewire/guiding catheter unit into the trachea under endoscopic visualization (Fig. 34.7). During insertion, slight resistance is encountered at the interface between the loading dilator and tracheostomy tube and when the balloon enters the trachea. The loading dilator, guiding catheter, and guidewire are removed and replaced with the inner cannula (Fig. 34.8). The cuff is inflated, and the ventilator tubing is attached to the tracheostomy tube. The tube is anchored with four corner sutures and tape ties. When adequate ventilation is assured, the patient can be safely extubated, and the vocal folds inspected as necessary.

Percutaneous tracheostomy using the balloon dilatation technique ("Blue Dolphin") involves radial dilatation of the tracheal aperture through controlled inflation of a balloon. Instruments in this kit include a scalpel, a curved mosquito, a no. 14 or 16 sheathed needle, a J-tipped guidewire, and a 14-French introducer dilator. In this system, the guiding catheter and single dilator are replaced by a single instrument consisting of a balloon catheter/loading dilator assembly, which is inflated using the ?Cook inflation device (Fig. 34.9). Prior to starting the procedure, the following preparations should be made: (1) The balloon catheter/loading dilator assembly is fitted with the appropriate tracheostomy tube (Fig. 34.10). (2) The inflation device is primed

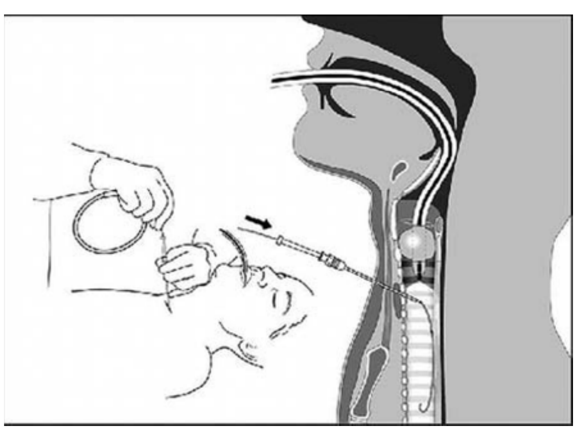

FIGURE 34.4
The needle is removed, and a J-tipped guidewire is threaded into the trachea through the remaining sheath. (From Myers EN. *Operative Otolaryngology: Head and Neck Surgery*. Philadelphia, PA: Saunders/Elsevier, 2008, with permission.)

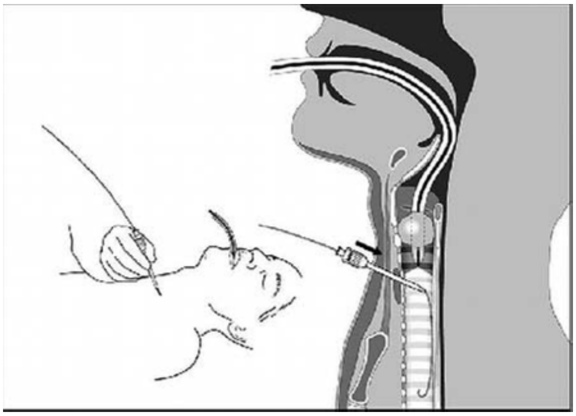

FIGURE 34.5 The sheath is replaced by a 14-French introducer dilator, which is also removed, leaving only the guidewire in place. (From Myers EN. *Operative Otolaryngology: Head and Neck Surgery*. Philadelphia, PA: Saunders/Elsevier, 2008, with permission.)

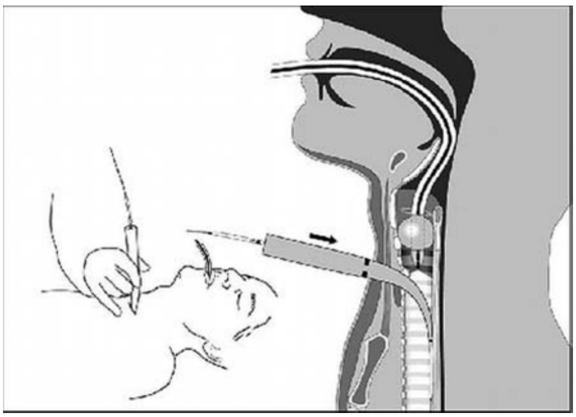

FIGURE 34.6 The single dilator/guiding catheter unit is dipped in saline to activate the hydrophilic coating and held like a pen as it is threaded over the guidewire between the markings and advanced into the trachea in an arc. (From Myers EN. *Operative Otolaryngology: Head and Neck Surgery*. Philadelphia, PA: Saunders/Elsevier, 2008, with permission.)

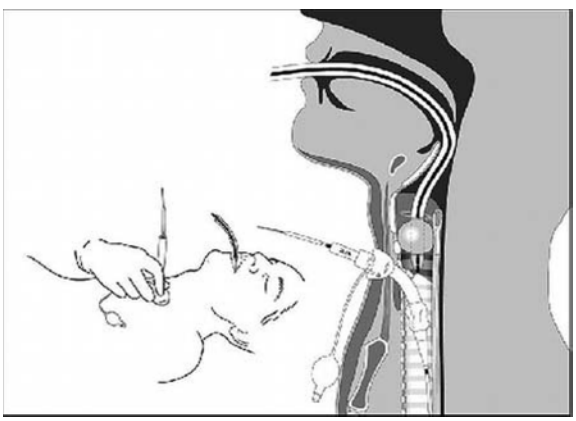

FIGURE 34.7 The single dilator is removed, and the preloaded tracheostomy tube is advanced over the guidewire/guiding catheter unit into the trachea under endoscopic visualization. (From Myers EN. *Operative Otolaryngology: Head and Neck Surgery*. Philadelphia, PA: Saunders/Elsevier, 2008, with permission.)

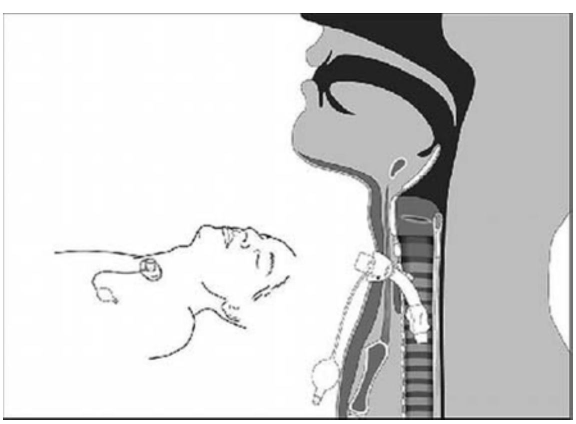

FIGURE 34.8 The loading dilator, guiding catheter, and guidewire are removed and replaced with the inner cannula. (From Myers EN. *Operative Otolaryngology: Head and Neck Surgery*. Philadelphia, PA: Saunders/Elsevier, 2008, with permission.)

FIGURE 34.9 Instruments for the "Blue Dolphin" or balloon dilatation technique. Above, from left to right: needle driver, forceps, suture scissors, 3-0 Ethilon suture for anchoring the tracheostomy tube in place, water-based lubricant for the tracheostomy tube, gauze, and a "sharps" container. Below, from left to right: scalpel, curved mosquito, sheathed and unsheathed needle (either one may be used), J-wire, introducer dilator in the center, balloon catheter/loading dilator assembly, inflation device, no. 6 tracheostomy tube with syringe, inner cannula.

with 20-mL sterile saline and attached to the side port marked "balloon." The first steps of this technique are identical to those using the single dilator setup until the point at which the guidewire is in place. The next step consists of advancing the balloon catheter/loading dilator assembly, preloaded with the tracheostomy tube, over the guidewire into the trachea until the black mark denoting the midpoint of the balloon is seen endoscopically. The balloon is inflated to a maximum of 11 atmospheres for a total of 10 seconds and then deflated (Fig. 34.11). The unit is then advanced into the trachea with the tracheostomy tube. The balloon dilator/loading catheter unit is removed and the inner cannula inserted and attached to the ventilator.

Tracheostomy tube size is chosen based on the clinical needs and gender of the patient. Whenever possible, smaller no. 6 internal diameter tubes should be used in females to reduce the likelihood of tracheal stenosis or tracheomalacia. In a patient with a short, thick neck, a longer tracheostomy tube should be used to prevent accidental displacement of the tube into the pretracheal soft tissues.

Depending on the degree of calcification of the tracheal cartilages, fracture of the ring immediately adjacent to the dilator may occur during dilatation. This is akin to intentionally incising one or more rings during an open surgical tracheostomy. This is no evidence to suggest that this occurrence increases the incidence of tracheomalacia and/or tracheal stenosis.

POSTOPERATIVE MANAGEMENT

Preoperative teaching of the patient and family is helpful in reducing anxiety and allowing for adjustment to the tracheostomy tube. A multidisciplinary tracheostomy team involving a physician, nurse, respiratory therapist, and speech–language pathologist should ideally assist with wound care, tracheostomy tube changes, swallowing, communication, decannulation, and teaching. The involvement of such a team results in a measurable decrease in postoperative morbidity: the frequency of tube obstruction decreases, the use of speaking valves increases, and patients are decannulated more rapidly.

In the immediate postoperative period, patients are positioned with the head of the bed elevated for comfort and to facilitate coughing and suctioning. Continued close monitoring of vital signs is important in preventing or immediately correcting potential problems. Once the stimulation associated with the procedure is over, the effects of the residual sedation may become evident with possible hypotension, tachycardia, or O_2 desaturation. Frequent suctioning of secretions, sometimes every couple of hours, is necessary to avoid obstruction of

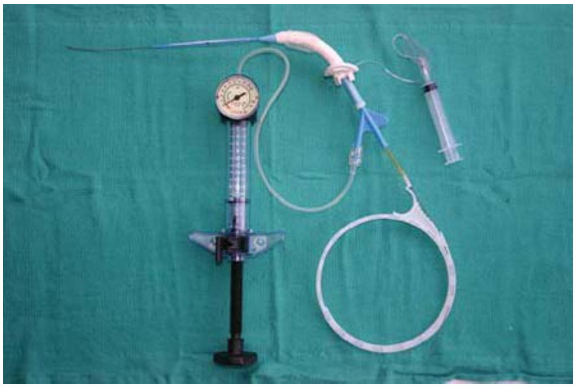

FIGURE 34.10 The balloon catheter/loading dilator assembly preloaded with the appropriate tracheostomy tube, in this case, a no. 6 Shiley. The assembly is advanced over the J-wire. Note the insufflation device secured to the side port.

FIGURE 34.11 Photo of the balloon catheter/loading dilator assembly preloaded with the tracheostomy tube. For illustration purposes, the inflation device has been primed with saline colored with methylene blue and the balloon is shown inflated.

the tube and a drop in saturation. Patient anxiety and agitation often signal a problem and should not be ignored, or even worse, treated with anxiolytics. A postoperative chest radiograph is almost always ordered to rule out a pneumothorax and/or pneumomediastinum. There is, however, no evidence to show that doing so in a routine, uncomplicated tracheostomy improves outcomes.

A tracheostomy tube with an inner cannula is the best and safest choice. Care and hygiene are easy, and the inner cannula can be quickly removed in the event of obstruction from secretions. Disposable inner cannulas should be changed frequently, and reusable cannulas should be cleaned regularly to avoid mucus plugging.

Tracheal suctioning is often necessary as frequently as three to four times daily, in a "fresh" tracheostomy, and should be performed as aseptically as possible. Since patients undergoing PDT are in the ICU on mechanical ventilation, suctioning "oxygen-rich" air through large catheters puts them at risk for hypoxia and cardiac arrhythmias. This can be prevented by ventilating the patient on 100% O_2 for five or more breaths before and after suctioning and limiting suctioning to ≤12 seconds with a small catheter. Alternatively, a closed, multiple-use suction catheter contained within a sheath may be used.

Humidification facilitates mucociliary transport and is crucial in preventing serious complications such as crusting, accumulation of secretions, and airway obstruction. It is usually delivered via a tracheal mask. T-tubes are best avoided because the torque exerted on the tube traumatizes the tissue every time the patient moves.

Meticulous local wound care is the key to preventing serious infection. This means cleaning the tracheostomy site three or more times daily with normal saline or hydrogen peroxide and keeping the area dry to prevent skin breakdown and progression from wound colonization to infection. Dressings under the neck plate and tapes holding the tracheostomy tube in place should be changed when soiled.

In contrast to open surgical tracheostomy, PDT is a dilatational technique with minimal tissue dissection and does not allow for placement of tracheal traction sutures. As a result, the tracheostomy tube fits very snugly in a tight tract, which takes several days to "mature." Because of this, the patient should be reintubated orally in the event of accidental decannulation within the first 5 to 7 days following PDT. Trying to forcefully replace a tracheostomy tube in an emergent situation is likely to result in bleeding, the creation of a false passage, pneumomediastinum, hypoxia, or even death.

If changing the tracheostomy tube is necessary prior to 7 days (e.g., ruptured cuff), the following careful preparation will minimize the possibility of difficulties (Table 34.3):

1. Optimal patient positioning
2. Assistance
3. Adequate light
4. Suction
5. Two tracheostomy tubes: ideal size and smaller size
6. Tracheostomy tube exchanger

TABLE 34.3 Requirements for Changing a Tracheostomy Tube ≤7 Days Prior to Insertion
• Optimal patient positioning
• Assistance
• Adequate light
• Suction
• Two tracheostomy tubes: ideal size and smaller size
• Tracheostomy tube exchanger

With the patient well positioned, and suctioned, the tracheostomy tube can then be changed over a tracheostomy tube exchanger. The latter is a long flexible hollow tube, which is sized to allow fitting with an adapter for ventilation. In this way, the airway is protected during the tracheostomy tube change. With the inner cannula removed, the exchanger is inserted into the existing tracheostomy tube, which is then removed and replaced with the new tube. The exchanger "guides" the new tracheostomy tube into the trachea. If for any reason the new tracheostomy tube is difficult to replace, ventilation may be temporarily continued through the exchanger.

Patients who do not require a cuffed tube may benefit from use of a Passy-Muir valve. This one-way valve opens for inspiration through the tracheostomy tube and closes on expiration, thereby deflecting air through the vocal folds and permitting phonation. As an added benefit, these valves also improve swallowing mechanics by restoring subglottic pressure. Contraindications for use of a speaking valve include a cuffed tracheostomy tube, upper airway obstruction, bilateral vocal fold paralysis (relative), severe tracheal stenosis, copious inspissated secretions, and cognitive dysfunction.

As the clinical situation improves, decannulation can be safely accomplished by following a few simple steps. Indirect or flexible endoscopy should be used to ensure that the upper airway is adequate and the larynx is competent. Granulomas projecting into the stoma should be removed. The tube may then be downsized and plugged during waking hours. The period of plugging allows for adequate evaluation of airway adequacy. It also affords time for laryngeal adductor reflexes to be activated. The patient must be instructed to remove the plug in the event of dyspnea or shortness of breath. If the plug is not tolerated further, the nature of the obstruction must be investigated before further attempts at decannulation. If the patient tolerates the plug for 24 hours, the cannula can be removed and the stoma covered with a light dressing and occlusive tape, which is changed as necessary. In the vast majority of cases, the stoma will close by secondary intention within a few days. The resultant scar from a transverse incision is cosmetically superior to that from a vertical incision.

COMPLICATIONS

Careful preoperative examination, appropriate patient selection, and attention to technical detail are all key ingredients in preventing postoperative complications. Technical differences between PDT and open surgical tracheostomy are significant, and proficiency in one technique does not translate into expertise in the other (Table 34.4). The point is that it is well worth investing the time to participate in a workshop, gain familiarity with the instruments, and have the opportunity to practice on mannequins or animal tracheas. When bringing the procedure to the bedside, "ideal cases" should be selected at first—that is, patients with a long, thin neck and landmarks that are easily palpable. These measures serve to reduce or eliminate the learning curve associated with endoscopic percutaneous dilatational tracheostomy, thereby also reducing the higher likelihood of complications seen in the first 30 to 40 cases.

The overall complication rate for endoscopic PDT in the literature is approximately 9% and compares favorably to that of ICU patients undergoing open surgical tracheostomy in the operating room, where complication rates of 14% to 66% have been reported or, at the bedside, where complication rates of 4% to 41% have been reported. Procedure-related mortality is very low for both PDT (.5%) and surgical tracheostomy (ST) (<2%). Comparative data on individual complications (e.g., bleeding, infection) for surgical and percutaneous tracheotomies vary widely, but overall PDT compares favorably to ST. Although the need for continuous endoscopic visualization has been debated in the literature, several series have shown that it is crucial to the safety of the procedure and in reducing the incidence of serious complications. It is this author's opinion that PDT should never be attempted without continuous endoscopic guidance.

Obese patients with a body mass index ≥30 are at higher risk for complications. This risk is further increased in obese patients with a higher American Society of Anesthesiologists classification. The most common complication in this group is accidental decannulation because of the thickness of the subcutaneous tissue. This problem can be largely, if not entirely, avoided by using a proximally extended tracheostomy tube in these patients. There are no data available on the risk of complications in obese patients undergoing open surgical tracheostomy and therefore no evidence that open surgical tracheostomy in the operating room is any safer in this group. While early mortality in morbidly obese patients undergoing ST may be higher than in nonobese patients, there are no comparable data on early mortality in obese patients undergoing PDT.

TABLE 34.4 Preventing Complications in Endoscopic Percutaneous Dilatational Tracheostomy
• Careful preoperative examination
• Appropriate patient selection
• Attention to technical detail
• Appropriate training in the procedure

TABLE 34.5 Intraoperative Complications
• Desaturation • Accidental extubation • Posterior wall injury • Technical errors • Hemorrhage • False passage, pneumothorax, pneumomediastinum

Potential complications for PDT are similar to those reported for surgical tracheostomy with a few notable differences, to be discussed below. For convenience, they are divided into intraoperative, immediate postoperative, and late postoperative complications.

Intraoperative Complications (Table 34.5)

Desaturation

Some degree of desaturation during either PDT or ST probably occurs frequently. Because it is usually brief and clinically insignificant, it is seldom reported. As a result, the real risk of this complication is unknown for both the "open" and percutaneous tracheostomy techniques. Brief episodes of mild oxygen desaturation may occur at the time of tracheostomy tube insertion, particularly in patients with compromised pulmonary function requiring high FiO_2 concentrations. The risk of such an occurrence may be minimized by thorough pre-/intraoperative suctioning of secretions and by ventilating all patients undergoing PDT on 100% O_2 for the duration of the procedure.

Accidental Extubation

The true incidence of accidental extubation for either PDT or open surgical tracheostomy is unknown because it is so infrequently mentioned in the literature. It has, however, been reported to occur with both techniques. The risk of this potentially serious complication may be reduced through the following steps: (1) the ETT should be held and manipulated only by a physician or a respiratory therapist; (2) the skin incision should be made prior to manipulation of the ETT; and (3) manipulation of the ETT should only occur after the bronchoscope has been positioned within the ET tube and while the patient is ventilated on 100% oxygen.

Posterior Wall Injury

Overinsertion of the needle may puncture the posterior wall, but this is clinically insignificant and is easily corrected by simply withdrawing the needle to the appropriate position. Serious posterior wall injury can be avoided by attention to technical detail such as proper positioning of the guidewire, guiding catheter and dilator, and, most importantly, constant endoscopic visualization of the posterior wall during the procedure. With endoscopic guidance, intraoperative tracheoesophageal fistula should never occur in PDT.

Technical Errors

Possible technical errors include loss of the puncture site and accidental removal of the J-wire. In these instances, the procedure must be continued from the previous step or restarted. Occasionally, resistance is encountered during dilatation. This may be because the incision and/or soft tissue "tunnel" is too small. As a rule, the surgeon's index finger should fit comfortably in the incision and soft tissue tunnel. If not, additional spreading of the soft tissue is needed to correct the problem. If the initial needle insertion is through a tracheal ring, dilatation will be difficult and the needle should be repositioned between rings. If the tracheostomy tube is difficult to insert, the tract should be "redilated." The use of excessive force during any step of the procedure always indicates a problem and should never be used. Instead, a few minutes should be taken to identify and correct the source of the problem in order to avoid complications. Technical problems may prolong the procedure but rarely directly impact patient safety or outcome.

Hemorrhage

The reported incidence of bleeding varies widely in the literature from 0% to 37% for open surgical tracheostomy compared to 1% to 19% for percutaneous tracheostomy. As with all surgical procedures, blood dyscrasias should be corrected preoperatively and anticoagulants stopped whenever possible.

Overall, the frequency of bleeding complications is lower in PDT compared to ST because of the blunt dilatational nature of the technique as well as the tamponade effect of the tracheostomy tube against the tight tract, which is created. For this reason, PDT may be the procedure of choice in adult intubated ICU patients with incompletely corrected coagulopathies or a mildly elevated INR.

The occasional bleeding encountered from a thyroid vein at the time of initial tracheal puncture can be managed by removing the needle, applying pressure for 5 minutes and changing the puncture site. Alternatively, the procedure may be continued at the original puncture site, since the bleeding will stop

with the tamponade effect of the tracheostomy tube. Minor oozing from wound edges can be controlled with simple pressure or a small hemostatic packing. True hemorrhage in PDT is rare and usually results from an unanticipated anatomical anomaly, from violating a major vessel, or, later, from erosion into the innominate artery.

False Passage, Pneumothorax, and Pneumomediastinum

These potentially fatal complications can be almost completely avoided by continuous bronchoscopic visualization of every step of the procedure. In PDT, the small incision, minimal blunt midline dissection, and endoscopic guidance virtually eliminate the possibility of injury to adjacent structures or the creation of a false passage. It is worth repeating that excessive force should never be used during dilatation or tracheostomy tube insertion and always indicates a technical problem.

Since PDT is performed on intubated patients, “air hunger” is not an issue, and posttracheostomy pulmonary edema is rarely if ever seen. Similarly, cautery is not used in PDT, and there is no risk of fire.

Immediate Postoperative Complications (Table 34.6)

Tube Obstruction

Tube obstruction is a potentially fatal complication caused by thick mucus or blood clots. It is unfortunately quite common and almost completely preventable with attentive nursing care, proper humidification, and frequent suctioning. Routine use of a tracheostomy tube with an inner cannula adds an important measure of safety and simplifies regular inspection, cleaning, and suctioning. If for some reason an obstructed inner cannula cannot be cleared, it can easily be removed and replaced.

Displaced Tracheostomy Tube

Displacement of the tracheostomy tube into the soft tissue is most likely to occur in the immediate postoperative period and is potentially fatal. Obese patients are at particular risk for tube displacement because of the inadequate length of standard tracheostomy tubes. Routine use of an extended length tracheostomy tube in these patients largely prevents this problem. Other patient factors, which may predispose to tube displacement, include excessive coughing and agitation. Suturing the neck plate and using neck tapes may also help prevent this complication. Displacement of the tracheostomy tube should be suspected when a patient with a recent tracheostomy develops respiratory distress or is suddenly able to speak. Because of the tight tract associated with PDT, patients should be reintubated for the 1st week postprocedure. Attempted reinsertion of the tube is an invitation to serious complications such as a false passage.

Postoperative Hemorrhage

Postoperative bleeding can occur when the vasoconstriction from the epinephrine wears off or from injured vessels. Treatment can almost always be provided at the bedside and consists of ligation of identifiable vessels or, more commonly, use of a hemostatic packing such as Surgicel for “oozing” around the wound. Coagulopathies, if present, should be corrected. Rarely, when bleeding is significant and cannot be controlled at the bedside, the patient should be transported to the operating room to obtain hemostasis.

Wound Infection

Reported infection rates vary widely from 0% to 10% for PDT compared to 0% to 31% for ST. Most large series and this author’s experience indicate a significantly lower risk of infection in PDT compared to ST. This is probably because of the small wound and tight tract, which reduces the surface area available for bacterial colonization compared to the more extensive soft tissue dissection in ST.

Within 24 to 48 hours, all tracheal wounds are colonized by many species of organisms, including *Pseudomonas* and *Escherichia coli*, as well as gram-positive cocci. Antibiotics simply select for colonization by resistant organisms and should not be used. Tracheostomy tubes are also colonized by bacteria such as *Staphylococcus epidermidis*, which are imbedded in biofilm. The longer the tube is in place, the heavier the load of biofilm. Regular tracheostomy tube changes every 2 weeks for admitted patients may decrease the incidence of granulation tissue and biofilm formation.

The key to preventing infection lies in meticulous wound care and hygiene. This includes regular suctioning, cleaning, dressing and tie changes, and tube changes when necessary to remove crusts and necrotic debris.

TABLE 34.6 Immediate Postoperative Complications
• Tube obstruction • Displaced tracheostomy tube • Postoperative hemorrhage • Wound infection • Subcutaneous emphysema

All these measures help reduce bacterial load. True infection with surrounding cellulitis is unusual and should be treated with organism-specific antibiotics as well as aggressive local wound care with debridement. Necrotizing stomal infections are rare, and this author has never seen one following PDT.

Subcutaneous Emphysema

Subcutaneous emphysema in association with PDT is rarely reported despite the tight tract and probably occurs in patients requiring elevated PEEP pressures of over 15 cm H_2O. For this reason, such patients should undergo ST. When subcutaneous emphysema does occur, it is usually mild and diagnosed by palpating crepitus in the tissues of the neck, chest, or face. Generally, no treatment is necessary because the air is slowly absorbed from the tissues.

Late Postoperative Complications (Table 34.7)

Granulation Tissue

Granulation tissue is considered to be a late complication of tracheostomy, occurring in 3% to 80% of cases. Factors that are thought to favor formation of granulation tissue include bacterial infection, biofilm on the tracheostomy tube, gastroesophageal reflux, suture material, and powder from surgical gloves. Regular tube changes on a schedule of every 2 to 3 weeks help reduce the incidence of this problem. A number of topical treatments such as steroid creams, antibiotic ointments, and silver nitrate have been tried, with mixed results. Larger amounts of granulation can cause bleeding and obstruction of the tracheostomy tube and may prevent or delay decannulation. For these reasons, problematic granulation tissue should be removed surgically, with or without the laser.

Tracheoesophageal Fistula

Late tracheoesophageal fistula is extremely rare and may result from an overinflated or improperly fitted cuff. A malpositioned tracheostomy tube pushed to the posterior wall of the trachea against an indwelling nasogastric tube may also result in the formation of a fistula. Penetration of the posterior tracheal wall should never happen during PDT because of continuous endoscopic guidance. Treatment consists of open repair with individual closure of the tracheal and esophageal defects and interposition of soft tissue, such as muscle into the defect.

Rupture of the Innominate Artery

Rupture of the innominate artery usually occurs within the first 3 weeks after tracheostomy and may be fatal. It is rare with both ST and PDT, and there are no comparative data available. Factors which may predispose to this complication include (1) placing the tracheal opening below the third tracheal ring or using an excessively long tube, where the inferior surface of the cannula erodes through the anterior tracheal wall into the artery; (2) aberrant or abnormally high innominate artery; (3) prolonged pressure on the tracheal wall by an inflated cuff; and (4) tracheal infection.

The first indication of possible innominate rupture comes as a "sentinel bleed," which usually stops, to be followed a few days later by a catastrophic hemorrhage. The patient coughs up large amounts of bright red blood from the tracheostomy tube. Swift action offers the best hope of saving the patient's life. The cuff of the tracheostomy tube should be overinflated immediately and suprasternal pressure applied in an attempt to control the hemorrhage. If the inflated tracheostomy cuff does not prevent blood from entering the lungs, it can be changed for an ETT, which can be advanced to the desired level and the cuff inflated to control bleeding and prevent aspiration of blood. These maneuvers generally control the bleeding at least temporarily. The patient should be cross-matched and transported to the operating room immediately, keeping continuous pressure between the anterior trachea and sternum. Sternotomy and ligation of the innominate artery is a lifesaving maneuver.

Tracheal Stenosis and Tracheomalacia

Tracheal stenosis and tracheomalacia are late complications. The limited data available on these complications indicate that they occur no more frequently in PDT than ST. Steps toward decreasing the occurrence of these sequelae include (1) proper placement of the tracheostomy tube between the first and third tracheal rings,

TABLE 34.7 Late Postoperative Complications
• Granulation tissue
• Tracheoesophageal fistula
• Rupture of the innominate artery
• Tracheal stenosis
• Tracheomalacia
• Tracheocutaneous fistula
• Depressed scar

(2) use of the smallest possible tube size, (3) minimizing cuff inflation pressures (<25 mm Hg), and (4) minimizing cuff inflation times.

Tracheocutaneous Fistula

Tracheocutaneous fistula is a persistent opening between the trachea and skin following decannulation. It results from inward growth of skin into the trachea. It is more likely to occur in long-standing tracheotomies. Another less frequent cause is partial upper airway obstruction, in which case the fistula compensates for the compromised airway. This is easily checked with an endoscopic examination prior to undertaking repair of the fistula. Tracheocutaneous fistulas are usually associated with a depressed scar.

A persistent tracheocutaneous fistula results in difficulty speaking or coughing without finger occlusion of the fistula, local skin irritation from mucus, and social embarrassment. The best repair involves removing a small ellipse of skin, which includes the fistula, and closing the fistula in layers. The top layer is skin, which is widely undermined laterally. The deeper layer consists of the strap muscles, which are released from the trachea and reapproximated in the midline with absorbable sutures. This effectively fills in the depressed area and separates skin from trachea. The skin is then closed and a light pressure dressing is applied to prevent air from escaping from the wound. Patients should be instructed to apply pressure to the area if they need to cough or speak for the first 48 to 72 hours.

Depressed Scar

A depressed scar is obvious and very visible because the skin is adherent to the trachea and moves every time the patient swallows. Repair involves excising the involved skin, widely undermining the edges of skin, dissecting out the strap muscles, and closing the wound in layers.

RESULTS

Percutaneous dilatational tracheostomy has emerged as an attractive bedside alternative to open surgical tracheostomy either in the operating room or at the bedside. Cumulative data over the past 20 years indicate that PDT is at least as safe as ST with comparable complication rates. Controversies in the literature regarding the necessity for bronchoscopic visualization in PDT have been discussed ad nauseum and largely been laid to rest by the weight of evidence demonstrating the important measure of safety the bronchoscope confers to the procedure. The risk of complications can be minimized by paying attention to the following: (1) adequate training in the procedure, (2) appropriate patient selection, (3) careful preoperative examination and optimization of comorbidities, (4) anticipation of potential problems, (5) careful preparation of instruments, (6) continuous endoscopic guidance and attention to technical detail, and (7) attentive postoperative care.

PEARLS

- Endoscopic PDT is only suitable in adult, intubated ICU patients.
- Appropriate patient selection is key and includes a clear understanding of the contraindications.
- A careful preoperative examination focused on the neck is important in anticipating any potential problems. For example, extended-length tracheostomy tubes should be used in obese patients.
- Patient comorbidities should be identified and optimized prior to PDT.
- Thorough preparation prior to starting PDT ensures a smooth and time-efficient procedure. This means preparing the medications, positioning the patient, verifying the bronchoscope, arranging the instruments in the order they are needed, ventilating the patient on 100% oxygen, and monitoring vital signs.
- Attention to technical detail is crucial in minimizing complications.
- Continuous endoscopic visualization reduces complications and is mandatory in all cases.
- A multidisciplinary tracheostomy care team positively impacts patient outcomes.
- Frequent suctioning, humidification, and meticulous wound care are key in preventing postoperative complications.
- Patient anxiety and agitation should prompt the surgeon to rule out tube obstruction.
- Tracheostomy tubes with an inner cannula are the safest choice because they facilitate cleaning and can be removed in the event of obstruction.
- Patients who are accidentally decannulated within the first 5 to 7 days post-PDT should be reintubated. The tract is too tight to allow for safe reinsertion of the tracheostomy tube.
- A tracheostomy tube exchanger is extremely helpful and protects the airway in instances when the tracheostomy tube must be changed prior to 7 days.
- Appropriate training in PDT and careful patient selection help reduce the learning curve and the likelihood of complications.

- Obese patients are at higher risk for accidental decannulation and should routinely be fitted with extended-length tracheostomy tubes.
- Complication rates for PDT compare favorably to ST. In particular, bleeding and infection occur less frequently in PDT because of the small tract and tight fit of the cannula.

PITFALLS

- Failure to thoroughly assess patient suitability for PDT preoperatively increases the risk of complications.
- Inadequate preoperative preparation—scrambling for instruments, tracheostomy tubes, and medications after the procedure has begun, when the airway is most vulnerable—increases operative time and the likelihood of complications.
- Assuming that proficiency in open surgical tracheostomy obviates the need for special training in PDT is an error.
- Oversedation of ICU patients during PDT may lead to rapid hypotension and tachycardia, particularly at the end of the procedure.
- The use of excessive force when resistance is encountered is an invitation to complications and should never be used. The problem should be identified and corrected.

INSTRUMENTS TO HAVE AVAILABLE

- Preassembled percutaneous dilatational tracheostomy kit using the single dilator contains scalpel, a sheathed and nonsheathed introducer needle, J-wire, introducer dilator, guiding catheter, single dilator, 26- and 28-French loading dilators, 5-mL syringe, and "sharps" container.
- Preassembled percutaneous dilatational tracheostomy using the inflatable balloon "Blue Dolphin" kit contains scalpel, a sheathed and nonsheathed introducer needle, J-wire, introducer dilator, balloon catheter/loading dilator assembly, inflation device, and a tracheostomy tube.
- Additional instruments not in the kit(s):
  - Kelly or other clamp for prepping
  - Curved hemostat/mosquito for spreading soft tissue
  - Straight (suture) scissors
  - A needle driver
  - Forceps
  - Nonresorbable suture(s)
  - Skin prep solution
  - Water-based lubricant
  - Additional sterile 4 × 4 gauzes
  - Sterile saline to activate the hydrophilic coating of the single dilator
  - Two 10-mL syringes
  - Appropriately sized tracheostomy tube

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35 PHOTODYNAMIC THERAPY OF EARLY LARYNGEAL CANCERS

Merrill A. Biel

INTRODUCTION

Cancer of the larynx accounts for 25% to 30% of all cancers of the head and neck. Early cancers of the larynx (Tis, T1, T2) and severe dysplasia are presently treated with either radiation therapy or surgery alone. Five-year cure rates achieved with this therapy, including surgical salvage, are 75% to 90%. Radiation therapy has the advantage of preserving the physical integrity of the larynx, thereby preserving the voice. Radiation therapy, however, has significant disadvantages even when small laryngeal fields of radiation are used. These disadvantages include discomfort and mucositis during and for potential prolonged periods after therapy, permanently altered quality of the voice, dysphagia, chondroradionecrosis of the larynx and trachea, and the extensive length of therapy (6 to 7 weeks). Surgical therapy for early cancers of the larynx, T1 and T2, includes performing a partial cordectomy or hemilaryngectomy. Although cure rates are high, surgical removal of portions of the vocal cord or hemilarynx results in significant alteration of the quality of the voice.

Severe dysplasia and Tis may also be treated with either radiation or limited surgery with either microsurgical techniques or laser excision. Le reported on 82 patients with Cis Tis of which 15 were treated with vocal cord stripping with a 56% local control rate, 13 were treated with extensive laser resection/hemilaryngectomy with a 71% local control rate, and 54 were treated with radiotherapy with a 79% local control rate. Involvement of the anterior commissure was a significant negative prognostic factor. Subjective quality of the voice was good to excellent in 73% of patients who underwent vocal cord stripping, 40% of those who underwent extensive resection, and 68% who underwent radiation therapy. Zeitels reported on seven patients with Tis undergoing microsurgical resection. Two patients developed subsequent microinvasive cancer requiring more aggressive treatment. Smith reported on 25 patients with Tis treated with surgical resection with an 88% cure rate. Sittel reported on laser excision of vocal cord cancers and noted significant effect on the quality of the voice with anterior commissure resections even when done in a staged fashion. Chone reported on 48 patients with early cancer of the glottis treated with laser microsurgical resection. He noted a 79% local control rate and a 96% laryngeal preservation rate. Rucci presented the results of 81 patients treated with CO_2 laser therapy for Cis Tis and T1 glottic cancers and noted a 35% recurrence rate.

Garcia-Serra reported on 30 patients with Tis treated with radiotherapy with an 88% local control rate. Review of the literature for radiotherapy of Tis demonstrated an 87.4% weighted local control rate at 5 years on 705 patients in 22 published reports.

Review of 10 reports of laser excision treatments of Tis demonstrated an 82.5% control rate in 177 patients. Many patients required multiple laser excisions.

Damm reported on 29 patients with Tis treated with laser excision. Seventy-six percent (22/29) required more than one laser excision for persistence of disease, 9 of which were in the anterior commissure. Two-year disease-free survival was 86%. Dysphonia was reported in all patients, and none had improved quality of the voice over the pretreatment state. A review of the literature of control rates of various treatments for Tis were as follows: laser excision (104 patients) 20% initial failure rate, 1% loss of the larynx; vocal cord stripping (235 patients) 34% failure rate, 12% loss of the larynx; and radiotherapy (481 patients) 16% failure rate, 7% loss of

the larynx. The literature therefore demonstrates that surgical techniques to treat Tis are best limited to those patients in whom the Tis does not involve the anterior commissure or both vocal cords.

Hafidh presented the results of 150 patients treated with radiotherapy for T1/T2 glottic cancers. Seventy-one percent of T1 and 63.3% of T2 cancers were controlled with radiotherapy with an average follow-up of 37 months. Hartl presented a review of treatment options for cancer of the glottis and using primary radiotherapy noted a 43% to 91% control rate for T1 cancers and a 50% to 85% control rate for T2 cancers.

Batalla performed a study of the quality of the voice in patients who underwent endoscopic laser surgery and radiotherapy for T1 glottic cancer and noted that the quality of the voice was affected both by surgery and radiotherapy, although there was a reduced impact on the patient's perception of the quality of the voice after radiotherapy.

The optimal treatment for severe dysplasia and early cancer of the larynx would be one that is effective, safe, repeatable, minimally invasive, nonsurgical, and a less time-consuming therapy than radiotherapy. Photodynamic therapy (PDT) is potentially such a treatment for severe dysplasia and early cancers of the larynx.

Photodynamic Therapy

PDT is a minimally invasive treatment involving the use of a photosensitizing drug and laser light for the treatment of a variety of cancers. When administered, these compounds are accumulated and retained to a greater degree in malignant tissues than normal tissues. The drugs remain inactive until exposed to a specific wavelength of light. The light, usually from a laser, is transmitted through specially modified fiber optics and activates the drug. The resulting photochemical reaction results in the production of oxygen radicals, thereby destroying diseased cells with little effect on normal tissues.

To date, PDT has been used to treat cancers in many organs, and Photofrin-based PDT has been approved by the U.S. FDA to treat early- and end-stage endobronchial and esophageal squamous cell cancers and Barrett dysplasia. Photofrin (porfimer sodium) concentrates in malignant tissue, is activated by penetrating light (630 nm + 3 nm), produces fluorescence, and is photochemically efficient. Photofrin has produced only one major adverse reaction as a result of its use: light sensitivity. Importantly, the use of Photofrin PDT to treat early cancer of the head and neck has been promising.

The generally accepted mechanism of action of PDT is that there is an energy transfer process from the light activated or excited triplet state of the photosensitizer to oxygen producing singlet oxygen, which in turn causes irreversible oxidation of some essential cellular component. It has also been shown that the vasculature changes within the tumor necrosis subsequent to PDT result in ischemia that is responsible for tumor necrosis. Either or both are sufficient to explain the remarkable necrosis of tumors within 2 to 5 days following PDT with Photofrin.

PDT has been demonstrated to be effective in the treatment of early cancers of the head and neck. The advantage of PDT therapy for early cancers of the larynx is the ability to preserve normal endolaryngeal tissue while effectively treating the cancers. This results in improved function of the larynx and the quality of the voice. Furthermore, PDT requires a short duration of therapy as compared to radiation therapy, is repeatable, carries less risk than surgical therapy, and is performed as an outpatient noninvasive treatment. Importantly, the use of PDT does not preclude the use of radiotherapy or surgery in the future for new primary or recurrent disease.

CLINICAL EXAMPLE

HISTORY

A 71-year-old male presents with a history of recurrent hoarseness. Two years prior he noted hoarseness and on medical workup was noted to have a hyperkeratosis of the right vocal cord. He underwent microlaryngoscopy and CO_2 laser excision of the right vocal cord lesion that on pathology demonstrated right vocal cord severe dysplasia. He then presented 2 years later with onset of hoarseness. There was no sore throat, dysphagia, hemoptysis, or shortness of breath.

PHYSICAL EXAMINATION

On laryngoscopy, he was noted to have a hyperkeratotic lesion along the right anterior vocal cord with surrounding induration. The lesion extended up to the anterior commissure and there was a slight area of hyperkeratosis along the free edge of the left anterior vocal cord, just opposite from the right vocal cord lesion. There was no cervical lymphadenopathy. Biopsies were obtained under microlaryngoscopy. The right vocal cord lesion histologically was a microinvasive squamous cell carcinoma, and the left anterior vocal cord lesion histologically demonstrated hyperkeratosis with moderate premalignant dysplasia. He was therefore staged as a recurrent T1aN0 squamous cell cancer of the right vocal cord with premalignant dysplasia on the anterior left vocal cord.

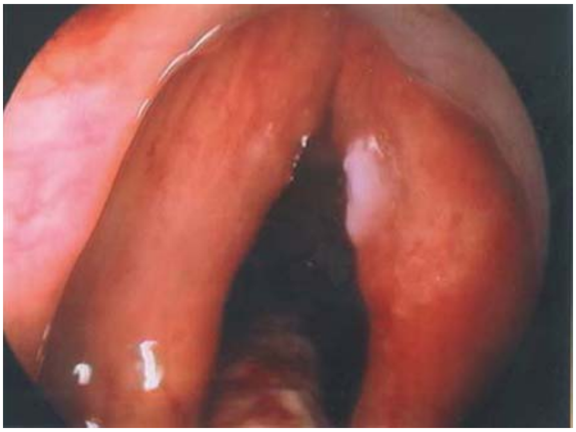

FIGURE 35.1 Recurrent squamous cell carcinoma of the right vocal cord T1a and dysplasia of the left anterior vocal cord.

PREOPERATIVE MANAGEMENT

T1N0 squamous cell carcinoma of the glottis has a number of good treatment options available with nearly equivalent cure rates. Microsurgical resection of the involved vocal cord and narrow field radiotherapy both provide excellent cure rates but have unique short- and long-term side effects and risks as previously discussed. PDT is a minimally invasive outpatient treatment that has been found in phase II clinical trials to provide at least the same cure rates as surgical or radiotherapy for Tis and T1 squamous cell cancers of the glottis with excellent functional voice results. As all of these treatment options provide for the same cure rates, it is important to discuss the various treatment options with the patient including each treatment's risks and benefits so that the patients may decide which treatment they would prefer to undergo for their cancer therapy. This patient chose to undergo PDT treatment for the cancer of the right vocal cord and premalignant dysplasia of the left anterior vocal cord.

SURGICAL TECHNIQUE

Photofrin was injected intravenously at a dose of 2.0 mg/kg over a 5-minute period as an outpatient procedure. Approximately 48 hours after the injection, the patient underwent general anesthesia induction and intubation with a 5.0 Xomed laser tube. Under standard microlaryngoscopy, the right vocal cord with the cancer was exposed (Fig. 35.1), and the normal left vocal cord is protected from light administration using a moist neurosurgical Cottonoid (Fig. 35.2). The area of light treatment is measured using a small ruler placed parallel to the vocal cord. The area to be treated includes the actual tumor and at least 5 mm of normal-appearing tissue. In this case, the area to be treated was measured to be 2.0 cm.

The calculation of the optimal amount of light delivered to the tissue to be treated is referred to as dosimetry. The required exposure time for PDT tumor treatment depends on the laser power output in Watts, the fluence rate measured in Watts/cm^2, and the fluence in Joules/cm^2. These relationships are expressed in the following equations:

Area to be treated: $\pi D^2/4$

Light dose (joules) = Watts × seconds

Exposure time (seconds) = Fluence (J/cm^2)/Fluence rate (mW/cm^2)

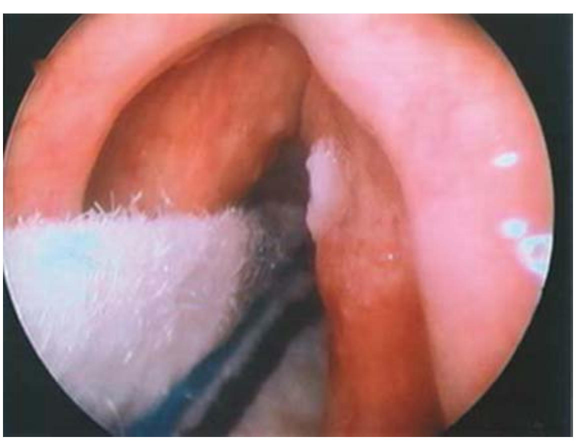

FIGURE 35.2 Cottonoid placed on left posterior vocal cord prior to PDT treatment to protect it from light administration.

The fluence (J/cm^2) and the fluence rate (mW/cm^2) to be administered to the tumor tissue is a predetermined number based on clinical trials for each specific tissue type and tumor to be treated. The amount of light (watts) coming out of the end of the treatment fiber (measured by a light power/wavelength meter) necessary to treat the tumor = the area to be treated in cm^2 × fluence rate (mW/cm^2). Importantly, the fluence and fluence rates (which are determined in clinical trials) will vary with each tissue treated and with each unique photosensitizer. In this instance, the light treatments were to be performed at 80 J/cm^2 and 150 mW/cm^2. The calculations for treatment of this patient were as follows:

Area to be treated with the microlens spot was $\pi D^2/4 = 3.14 \times (2.0\ cm)^2/4 = 3.14$ cm.

Total light output from end of the microlens fiber to treat a 2- cm spot at a fluence rate of 150 mW/cm^2 was area to be treated × fluence rate = 3.14 cm^2 × 150 mW/cm^2 = 471 mW or 0.47 W. Using the light meter on the laser, the laser light output out of the end of the microlens fiber was then adjusted to 0.47 W. The *length of time of light illumination* of the tumor was the fluence divided by the fluence rate × 1,000 = $J/cm^2/mW/cm^2$ × 1,000 mW/W = 80 J/cm^2/150 mW/cm^2 × 1,000 = 533 seconds. The laser time of illumination is then set to 533 seconds.

Using an Nd: Yag pumped-dye laser (Laserscope) at 630 nm wavelength, light was delivered to the tissue bed with a 400-μm fused silica optical microlens fiber (Laserguide, Inc., Buellton, CA). The light treatment was performed at 80 J/cm^2 and 150 mW/cm^2. So for a 2-cm tumor treatment area, total light output from the microlens fiber was 0.47 W and light was delivered for a period of 533 seconds.

POSTOPERATIVE MANAGEMENT

On completion of treatment, the patient received one dose of Decadron 10 mg intravenously to reduce edema of the tissue. With Photofrin PDT, when normal tissue is exposed to the 630-nm light, the limited amount of Photofrin in the normal tissues will be activated, resulting in edema of the tissue. This reaction occurs immediately so that by the end of the light illumination, the edema is maximal. Therefore, the patient was observed in the recovery room for 2 hours posttreatment in order to ensure that the airway was stable. Due to the acute edema, the patient immediately had a whispery voice that resolved over the ensuing 2 weeks. After 2 hours of airway observation, with a normal airway, the patient was discharged to home with oral pain medications. He was instructed to avoid daylight outside for 30 days; standard room light exposure causes no problems. He was instructed to proceed with a normal diet as tolerated, and there are no restrictions on voice use. Tumor response was evaluated at 2 weeks, 1 month, and then every 3 months thereafter. Multiple biopsy specimens of the treated area were obtained 1 month after treatment that demonstrated a complete histopathologic response (Fig. 35.3). This patient has remained free of disease for over 5 years.

COMPLICATIONS

The side effects of PDT treatment of laryngeal cancers are quite minimal as compared to conventional radiotherapy or surgery. PDT treatment is performed as a single outpatient procedure as compared to 6 to 7 weeks of radiotherapy or the hospitalization associated with a partial or total laryngectomy. The photosensitivity of Photofrin is a temporary inconvenience not associated with systemic toxicity and is minimized by patient education and temporary changes in daily outdoor activities. The photosensitivity does, however, last for approximately 4 to 6 weeks.

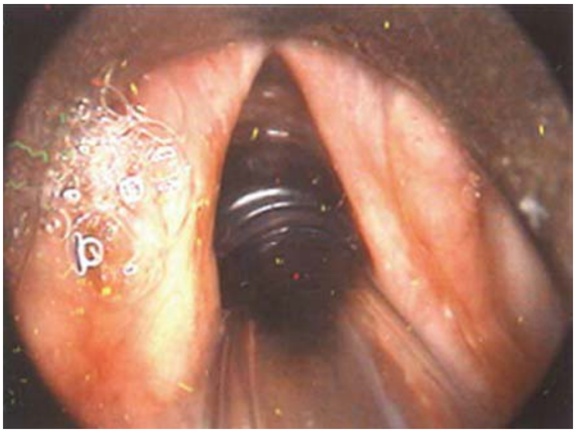

FIGURE 35.3
Four weeks after PDT treatment of recurrent right vocal cord cancer and left vocal cord dysplasia with resolution of disease.

RESULTS

Patients with premalignant dysplasia, early-stage cancers, or early recurrent cancer of the larynx (Tis, Tl, T2) tend to have an excellent response to PDT. Of 195 patients in this group treated with PDT, there was a durable complete response rate of 88.7% with up to an 18-year follow-up.

Multiple centers have reported phase II study data on the use of Photofrin-based PDT to treat Cis Tis-T2 cancers of the larynx (Table 35.1). Freche (1990) reported on 32 patients with T1 vocal cord cancers treated primarily with PDT. Twenty-five of thirty-two patients obtained a complete response for a complete response rate of 78%. Feyh (1996) treated 12 patients with Tis-T2 laryngeal cancers. Eleven of twelve patients obtained a complete response for a complete response rate of 91%. Gluckman (1991) treated two patients with T1 cancers of the larynx, both of which obtained a complete response. Schweitzer (2001) treated 10 patients with Tis-T2 cancers of the larynx, of which 8 obtained a complete response for an 80% complete response rate. I published the largest series of PDT treatment of laryngeal and oral cancer. One hundred thirty-three patients with recurrent or primary Tis, T1N0, and T2N0 laryngeal cancers were treated with PDT for cure. Three patients had recurrent Tis; 115 patients had T1N0 cancer of the true vocal cord, of which 25 were radiation failures; and 15 patients had T2N0 cancers of the true vocal cord, 8 of which were radiation failures. All patients obtained a complete histopathologic response after a single light treatment. With follow-up to 211 months (mean 96 months), there were 11 recurrences for a 5-year cure rate of 90%. Importantly all the recurrences were salvaged using PDT, surgery, or radiation for a total of 5-year cure rate of 100%. No patient required a total laryngectomy. In the entire treatment group, there were no episodes of airway compromise. At 4 to 6 weeks after treatment, the quality of the voice was universally much improved over the pretreatment state. In addition, videostroboscopy 6 weeks post-PDT treatment demonstrated a normal vocal cord mucosal wave on the treated vocal cord. Rigual (2009) treated six patients with severe dysplasia and T1 glottic cancers. Five of six patients obtained a complete response.

Dilkes treated five patients with T1-T2 laryngeal tumors with Foscan PDT. Only one of the five patients had no recurrence of disease. Grossman reported on the treatment of one patient with the use of oral Levulan PDT to treat a patient with multiple recurrent glottis severe dysplasia despite CO_2 laser excisions and vocal fold strippings. They demonstrated a complete response after one treatment and the patient remains free of disease for 6 months.

The present clinical series demonstrates the efficacy of Photofrin-mediated PDT as a curative treatment for Tis, T1 (85% to 91%), and T2 (72%) squamous cell cancers of the larynx that is at least as good if not better than the cure rates of surgery (65% to 80%) or radiotherapy (43% to 91%). PDT for laryngeal cancer results in no glottic scarring as compared to conventional laser or surgical excision or vocal cord stripping. For recurrent cancers of the larynx that have failed conventional radiation therapy, PDT allows excellent preservation of the voice and may eliminate the need for partial or total laryngectomy. Also, PDT can be repeated without additional functional laryngeal compromise that can occur from repeated conventional laser surgery or cordectomy. Importantly, PDT treatment of primary Tis, T1, and T2 laryngeal cancers reserves radiation therapy for treatment of recurrences or of second primary cancer of the head and neck that may occur in these high-risk patients.

PDT for treatment of Tis, T1, and T2 laryngeal cancers in the present series has cure rates that are comparable to if not better than that of conventional therapies with less morbidity of treatment. PDT should be considered as a reasonable option for the treatment of primary and recurrent Tis, T1, and T2 squamous cell cancers of the larynx.

TABLE 35.1 Summary of Published Results with Photofrin PDT of Early Squamous Cell Cancer of the Larynx

				Response, n		
Study	Patients	Lesion and Site	Drug, Dose, mg/kg	Complete	Partial	None
Feyh et al.	12	T1 and T2, larynx	Photosan III	11	1	0
Freche et al.	32	T1, larynx	HPD, 3	25	7	0
Schweitzer	10	T1, larynx	Photofrin, 2	8	2	0
Gluckman	2	T1, larynx	Photofrin, 2	2	0	2
Biel	133	Tis, T1, and T2 larynx	Photofrin, 2	122	11	0
Rigual	6	Severe dysplasia and T1 larynx	Photrofrin, 2	5	0	1

PEARLS

- PDT for treatment of severe dysplasia, Tis, T1, and T2 larynx cancers is a safe and effective alternative to traditional surgery or radiation therapy.
- Cure rates of PDT treatment of early cancers of the larynx cancers are comparable to surgery or radiation therapy, and PDT treatment has less functional morbidity as compared to traditional treatment methods.
- Complications of PDT are avoided by covering normal tissues during light treatment to prevent normal tissue edema.
- Patient education with regard to limited skin photosensitivity will prevent posttreatment skin light reactions.
- The technical skills and instrumentation required for performing PDT of the oral cavity and larynx are similar to those used for other oral and endoscopic laryngeal procedures.

PITFALLS

- Not protecting normal tissue with Cottonoid during light treatment will result in edema of the normal tissue.
- Posttreatment skin light reactions may be avoided by patient education with regard to limited skin photosensitivity.
- Edema in the treated area may be reduced by administering intravenous steroids within 1 hour *after* PDT treatment.
- The patients airway should be under observation for 2 to 3 hours after light treatment prior to discharging the patient home in case of unexpected airway problems.

INSTRUMENTS TO HAVE AVAILABLE

- Suspension laryngoscope
- 0 degree telescope
- Open ended laryngeal suction
- ½ × 3 inch neurosurgical cottonoid

SUGGESTED READING

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Hafidh M, Tibbo J, Trites J, et al. Radiotherapy for T1 and T2 laryngeal cancer: the Dalhousie University experience. *J Otolaryngol Head Neck Surg* 2009;38:434–439.

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